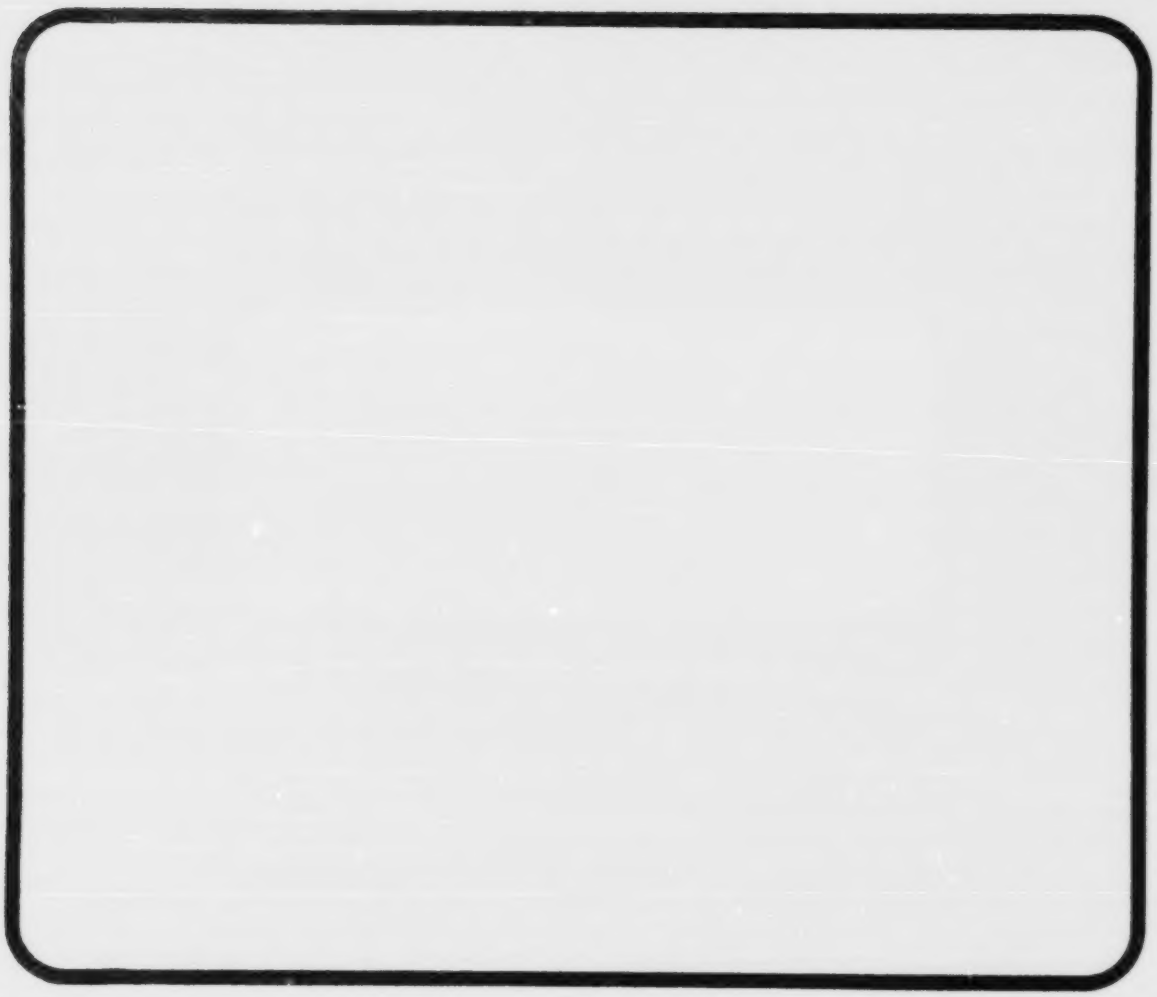
WORKPLACE SAFETY AND HEALTH



Manitoba
Environment and
Workplace Safety
and Health

1000 — 330 St. Mary Avenue
Winnipeg, Manitoba
R3C 3Z5

(204) 945-3446

G-6292

FLIN FLON:

A REVIEW OF ENVIRONMENTAL

AND HEALTH DATA

J. Manfreda,

Department of Medicine,
and
Department of Social and
Preventive Medicine,
University of Manitoba

I. Sabesky,

Department of Environment and
Workplace Safety and
Health
Workplace Safety and
Health Division

MAY, 1987

TABLE OF CONTENTS

EXECUTIVE SUMMARY

SUMMARY REPORT

I PUBLIC PERCEPTIONS OF HEALTH PROBLEMS IN FLIN FLON

II GENERAL ENVIRONMENT OF FLIN FLON

III OCCUPATIONAL ENVIRONMENT IN HUDSON BAY MINING AND SMELTING CO.

IV MORTALITY IN FLIN FLON, MANITOBA, 1959-1983

V MORBIDITY IN FLIN FLON

VI MAPPING OF CANCER INCIDENCE IN MANITOBA BY GEOGRAPHIC LOCALE: RESULTS FOR FLIN FLON

VII OCCUPATIONAL LUNG DISEASE SURVEILLANCE

VIII FEASIBILITY STUDY OF DEATH CERTIFICATES

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report was commissioned in the summer of 1985 by the Workplace Safety and Health Division of the Manitoba Department of Environment and Workplace Safety and Health. It addresses long-standing concerns about possible effects that the general and/or industrial environment might have on the health of residents in Flin Flon. These concerns were raised by both the Unions and the management of the Hudson Bay Mining and Smelting Co. (HBM&S) as well as other residents of Flin Flon.

The specific objectives of this report were to determine if:

1. available data indicated a possibility of an adverse effect of the general environment on health of the Flin Flon population;

2. available data indicated a possibility of an adverse effect of the occupational (HBM&S) environment on health of the Flin Flon population;

3. a further study of the relationship between either the general or industrial (HBM&S) environment and health is needed;

4. such a further study was feasible.

All available documents and data pertaining to the general environment

of Flin Flon, the occupational environment in HBM&S and the health status of Flin Flon residents and HBM&S employees were reviewed. Detailed results of this review are presented in eight chapters which represent the main body of this report. In the Summary Report the findings are discussed and conclusions are drawn.

During the summer of 1985 residents of Flin Flon were interviewed in order to determine their opinions and concerns about the health effects of the industrial (HBM&S) environment and of the general environment in Flin Flon. The objective was not to interview a representative sample of Flin Flon residents but rather to obtain as comprehensive a list of concerns as possible. Interviews were specifically requested from the representatives of the unions representing workers at HBM&S. Local media was used to extend an invitation to all residents to talk to the interviewer. In addition, reports in newspapers about the working and general environment health issues in Flin Flon were reviewed.

Conversations with union leaders and workers at HBM&S as well as with residents of Flin Flon indicated that people were concerned about the effects that the mining and smelting operation might have on the health of those who work inside HBM&S and those who live in the vicinity of the operation. Opinions ranged from none or little concern to extreme concern.

Flin Flon is a community of approximately 8,000 people who live beside the fourth largest mining and metallurgical complex in the country.

During the 1970's people were becoming increasingly aware of health hazards at work as well as risks that industrial emissions might represent for their communities. This awareness was heighten through the publication of reports on towns similar to the situation in Flin Flon. In view of this it is not surprising that some Flin Flon residents are concerned about their health and their environment.

There are only fragmentary data on exposures in the work or general environment before 1974. More extensive monitoring of the general environment and HBM&S working environment has been conducted since 1974.

The review of general environmental data indicated that HBM&S is the major source of environmental pollution in Flin Flon. Sulfur dioxide and particulate matter containing heavy metals are discharged into the environment through the HBM&S stack. These emissions also produce loading of surface waters and soil in the area. In addition, waste from HBM&S is discharged via the tailings pond into the surface water system.

The construction of the 250 meter stack in 1974 and the installation of a new electrostatic precipitator in 1982 reduced the levels of pollution with sulfur dioxide and particulates, respectively, in Flin Flon.

The effects of emissions produced by HBM&S are seen in vegetation,

small animals (mammals) and fish in the area within 40 km of the smelter. The reduction of emissions resulted in documented reductions of these effects.

The HBM&S work environment is very complex. It involves mining, smelting and refining of metals, as well as a variety of supporting jobs. Some areas of the industry are technologically old. High exposures remain in some areas. While some contaminants or combinations of contaminants affect only small groups of workers, there are contaminants to which large groups of workers are exposed: dust containing silica and/or heavy metals, sulfur dioxide, and sulfuric acid.

Several sources of morbidity and mortality data were reviewed to determine if diseases occurred more frequently in the population of Flin Flon than in the rest of the province. Most of these sources are "soft" and possible biases could not be properly controlled. The results of the analyses of data from the National Mortality Database, Provincial Cancer Registry and Manitoba Health Services Commission should be interpeted cautiously since they could be affected by migration pattern of the population or by other factors such as ethnic origin.

An increased occurrence of some health problems in Flin Flon, particularly cancers, respiratory diseases and injuries/accidents, was suggested by the mortality statistics, Cancer Registry data and

morbidity/medical services utilization data.

Analysis of the mortality pattern between 1959 and 1983 showed that in comparison with the provincial average, male residents of Flin Flon were more likely to die of cancers; cancer of the trachea, bronchi and lung; COPD (chronic obstructive pulmonary disease); or because of an accident. Female residents were more likely to die from respiratory diseases. Mortality in Flin Flon was also higher than in most of the five communities of similar size in Manitoba (The Pas, Dauphin, Portage La Prairie, Brandon, Steinbach). Cancer mortality data were consistent with Cancer Registry data. For all ages, the utilization rate of health services between 1981 and 1984 was higher in Flin Flon than in the province for diseases of the respiratory; digestive; musculo-skeletal system; and for injuries. For the age group 0-4, the utilization rate was higher for the genito-urinary system and for congenital anomalies.

Although the health services utilization rates suggested an increased rate of congenital anomalies in Flin Flon, this was not confirmed by data obtained from the Manitoba Congenital Anomalies Registry.

Sources of mortality or morbidity did not provide evidence that there was an increased risk of ischemic heart disease in the Flin Flon population.

The increased occurrence of cancers, COPD, and injuries in Flin Flon could be due to a variety of causes. Smoking is the foremost causal

factor to be considered for cancer of trachea, bronchi, and lung and for COPD. Unfortuately, data were not available to examine if differences between Flin Flon and the province, and Flin Flon and other communities could be explained by differences in smoking.

Data were examined to determine if there was evidence that an elevated occurrence of these diseases could be due to factors in the general environment of Flin Flon or in the HBM&S working environment. It was difficult to interpret data from males because the majority of males in Flin Flon were at one time employed by HBM&S or were occupationally exposed to the mining/smelting industry elsewhere.

On the other hand, only a small number of females had a history of exposure to the HBM&S working environment. Female mortality in Flin Flon was generally not elevated in comparison with the province as a whole or with females in five other communities. Unfortunately, we do not have good markers of environmental health effects for children except congenital anomalies. Data does not suggest a relationship between the incidence of congenital anomalies and the general environment.

In the absence of more sensitive measurements of health, observations on females and children are not consistent with the hypothesis that factors in the general environment increased the risk of disease and death in Flin Flon.

The fact that the excess mortality due to cancers and COPD was found in males and not in females, suggests the possibility that occupational factors may be responsible for this excess.

There is further evidence that occupational factors might be associated with the development of certain cancers. First, among those who died in Flin Flon between 1952 and 1984, the proportion of deaths attributed to cancers (all cancers, cancer of the trachea, bronchi, lung) was greater among those deceased residents of Flin Flon with a history of HBM&S employment than among those who were never employed by HBM&S. Second, the occupational histories of HBM&S employees who died from cancer (all cancers and cancer of the trachea, bronchi, and lung) differed from occupational histories of those HBM&S employees who died from other causes, suggesting a different type of exposure.

The evidence for the importance of occupational factors for COPD is forthcoming from a study of lung function changes in 972 employees of HBM&S between 1976/77 and 1983. There were significant differences in the decline of FEV_1 (forced expiratory volume in 1 second) between different exposure groups. The FEV_1 decline was greater in groups exposed to high concentrations of sulfur dioxide, total dust and sulfuric acid than in groups with lower exposures.

While data indicate that the industrial exposures at HBM&S are a possible explanation for the excess of certain cancers and COPD in Flin

Flon, it should be emphasized that the evidence is not definitive. Definitive answers are not possible on the basis of data presently available. The present data cover only a subset of HBM&S employee, i.e. those who were residents of Flin Flon and the effect of possible biases could not be evaluated.

If the information about the relationship between the HBM&S industrial environment and health is desired, an epidemiological study would be necessary. In such a study morbidity and mortality would be related to occupational exposures. The role of smoking would also have to be addressed. It has been determined that such a study is technically feasible.

On the basis of data reviewed, it is concluded that:

1. Residents of Flin Flon and employees of HBM&S are concerned about possible health effects due to occupational and general environmental exposures caused by HBM&S operations.

2. Industrial emissions and discharges, particularly sulfur dioxide and heavy metals, pollute the air, surface waters and soil in Flin Flon and surrounding area. The levels of in-town pollution from sulfur dioxide have been reduced since 1974 when the 250 m stack was constructed and those of heavy metals since 1982 when the electrostatic precipitator was installed. The emissions and levels of pollution in the City of Flin Flon and the surrounding area

should continue to be monitored in a systematic manner.

3. Effects of discharges from the industry are detected in small animals and vegetation in the area up to 40 km of the HBM&S complex.

4. The industrial environment of HBM&S is very complex. Large numbers of workers exposed to some contaminants or their combinations. Underground, the predominant contaminants are respirable dust containing silica and fumes resulting from operating diesel equipment and blasting. In the smelter and in most of the zinc plant, the predominant contaminants are metal fumes (total dust) containing zinc, copper, lead, cadmium, and arsenic. Sulfuric acid is present in the electrolytic tankhouse. Technological changes have reduced some exposures over time. Continued high exposures, even above TLV levels, are well documented for some areas and some jobs. Exposure of workers should continue to be monitored. For some groups of workers (for example underground employees and those who regularly change the area of work), exposure is poorly documented and steps should be undertaken to obtain adequate estimates of their exposure.

5. Adequate estimates of exposures prevailing in the general and in the working environment are essential for evaluation of the impact of technological development on these levels and of the impact on these levels on vegetation, animals and humans living in

the contaminated environment.

6. Review of available mortality and morbidity data suggests a statistically significant excess of cancers, respiratory disorders and injuries in the male population of Flin Flon. The available morbidity data are consistent with findings of the mortality analysis.

7. The industrial environment of HBM&S is more likely responsible for this excess of morbidity and mortality than the exposures in the general Flin Flon environment. Some of the excess could be due to smoking.

8. The presently available data are insufficient to evaluate in a definitive manner the role of occupational exposures for the development and for the excess of cancers and respiratory disorders.

9. An epidemiological study of the working population of HBM&S could resolve the question of the relationship between the occupational exposures and development of diseases.

10. An epidemiological historical cohort study to determine risks of diseases associated with job exposures is feasible. It is possible to identify the population at risk. It was demonstrated that it is possible to determine the types of exposures, and compile working

the operation in Flin Flon. The follow up methodology to ascertain causes of death is also available.

FLIN FLON:

A REVIEW OF ENVIRONMENTAL AND HEALTH DATA

SUMMARY REPORT

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SUMMARY OF CHAPTERS	3
Public Perceptions of Health Problems in Flin Flon	3
General Environment of Flin Flon	4
Occupational Environment in HBM&S	6
Mortality in Flin Flon, Manitoba, 1959-83	8
Mapping of Cancer Incidence in Manitoba by Geographic Locale: Results for Flin Flon	9
Morbidity in Flin Flon	10
Occupational Lung Disease Surveillance of HBM&S Employees	10
Feasibility Study of Death Certificates	11
DISCUSSION	12
CONCLUSIONS	17

INTRODUCTION

This report was commissioned in the Summer of 1985 by the Workplace Safety and Health Division of the Manitoba Department of Environment and Workplace Safety and Health. Its intent was to address long-standing concerns about possible effects that the general and/or industrial environment might have on the health of residents in Flin Flon. These concerns have been, over the years, raised by both the unions and the management of the Hudson Bay Mining and Smelting Co. (HBM&S) as well as by other residents of Flin Flon.

The objectives of this report are to determine if:

1. available data indicate a possibility of an adverse effect of the general environment on the health of the Flin Flon population;

2. available data indicate a possibility of an adverse effect of the occupational (HBM&S) environment on the health of the Flin Flon population;

3. a further study of the relationship between either the general or industrial (HBM&S) environment and health is needed; and

4. such a further study is feasible.

The City of Flin Flon is located on the Manitoba-Saskatchewan border, approximately 700 km north-west of Winnipeg. It developed in the vicinity of the HBM&S mining and metallurgical complex which continues to this day to be the major industry and employer in the area. Between 1950 and 1980, the population of Flin Flon varied between 8,000 to 10,000 (Census Canada, 1951-1981).

The mining and smelting operation began around 1930. The discovery of the ore body in the area had been made about fifteen years earlier. The mining and metallurgical complex of HBM&S is the source of environmental health concerns in Flin Flon. This concern includes the health of people who work in mines and surface departments of HBM&S as well as the health of the general population which resides within 5 km of the 250 m tall stack.

The concerns about the environmental and health impacts of the HBM&S operation had been raised before 1985. In 1974 a new 250m stack was constructed. In 1981, the Clean Environment Commission (CEC) limited the emissions from HBM&S in order to reduce the impact of emissions on the environment and health. Over time, some technological changes introduced by HBM&S resulted in reduction of some exposures. There is, however, a continuing concern that many exposures are still too high. Although some data about the environmental exposures were available, their relationship to the health status of either HBM&S employees or the general population of Flin Flon was never examined. In the late 1970's, HBM&S initiated a study to determine if occupational exposures

resulted in an increased incidence of disease. This effort was abandoned a few years later without producing any results.

In order to achieve the objectives of this study, all available documents and data pertaining to the general environment of Flin Flon, the occupational environment in HBM&S and the health status of Flin Flon residents and HBM&S employees were reviewed. It should be emphasized that this report is limited ot the analysis of secondary data. Detailed results of this review are presented in eight chapters which represent the main body of this report. The size of the individual chapters reflects more the availability of information than the importance to answer the principal questions addressed by the report. Each chapter was prepared independently of each other. In the summary report an attempt is made to summarize the main findings of individual chapters and to answer the specific objectives of the report.

The chapter on "Public perception of health problems in Flin Flon" summarizes what has been learned from conversations with selected residents of Flin Flon and Union leaders about health and environmental concerns.

Environmental exposures data are presented in the chapters entitled "General environment of Flin Flon" and "Occupational Environment in HBM&S".

In the chapter "Mortality in Flin Flon, Manitoba, 1959-83", the mortality pattern in Flin Flon was compared with mortality in Manitoba as a whole, and in each of five Manitoba and one Saskatchewan communities over the same time period.

The provincial Cancer Registry data are presented in the chapter entitled "Mapping of cancer incidence in Manitoba by geographic locale: results for Flin Flon".

In the chapter "Morbidity in Flin Flon", the utilization of medical service by diagnostic groups was reviewed for the population of Flin Flon and compared to the provincial coverage.

Prevalence of pneumoconioses and chronic airflow obstruction is reviewed in the chapter "Occupational lung disease surveillance of employees of HBM&S".

Finally, the feasibility of studying the information from death certificates and of constructing occupational histories for employees of HBM&S is discussed in the chapter entitled "Feasibility study of death certificates".

SUMMARY OF CHAPTERS

Public Perceptions of Health Problems in Flin Flon

During the summer of 1985, residents of Flin Flon were interviewed in order to determine their opinions and concerns about the health effects of the industrial (HBM&S) environment and of the general environment in Flin Flon. The aim was to identify those health effects about which the residents of Flin Flon were most concerned. It was not intended to interview a representative sample of the residents of Flin Flon but rather to obtain as comprehensive a list of concerns as possible. All residents were invited through the local media to talk to the interviewer. Interviews were specifically requested from the representatives of the unions representing workers at HBM&S. In addition, reports in various newspapers about the health consequences from the working and general environment in Flin Flon were reviewed.

On the basis of conversations, the interviewer concluded that there was, in Flin Flon, a wide range of opinions about the relationships between the working (HBM&S) and general environment and health of the population. While there were some residents who thought that the local environment had nothing to do with their health, there were others who were prepared to blame the environment for everything. The impression of the interviewer was that the majority of the 53 residents interviewed were somewhat concerned about the effect that the working and the general environment might have on the health of those living and working in Flin Flon. When approached, most residents were interested enough to discuss the problem. The interviewer noticed a difference between the older and younger workers. Older workers were more likely to give the impression that they accepted the risks and dangers of a job as a fact of life, consider themselves fortunate, and were grateful to the company for providing a job which enabled them to lead a fulfilling life. Younger workers were less likely to accept risks associated with work.

The general public was most concerned about respiratory disorders, cancers and heart problems, particularly heart failure. Interviewees were most concerned about the smelter, zinc plant, tankhouse, mine and crusher operations at HBM&S. Among the general environmental problems, the predominant concerns were acid rain and water pollution, particularly from heavy metals. Interviewees pointed out the psychological effects of living in a mining town where hard work and work risks are combined with a fast paced lifestyle which included excessive smoking and drinking. The construction of the 250m tall stack was perceived as a major, positive change for the environment of Flin Flon. Interviewees worried about the perceived lack of proper medical services.

In discussions with the union leaders of HBM&S (Trades and Steelworkers), it became clear that the unions had major concerns about the health risks to their members. Obviously, these concerns varied

somewhat from union to union since members of each union experienced different exposures and risks. All Union leaders were unanimous about the need to improve health and safety conditions in the plant. They hoped to achieve this by pointing out risks and dangers which they faced while working. They also hoped to convince the management about the positive cost-benefit ratio of investments in a better working environment.

Local media had on several occasions in the past highlighted environmental concerns. In addition to local media, CEC hearings provided another public forum for expressing some concerns.

General Environment of Flin Flon

The purpose of this chapter was to describe the general environment of the Flin Flon area and to identify those environmental factors which might have had an adverse effect on human health.

The work was accomplished by reviewing published and unpublished reports and documents available from the Manitoba Environment Management Division (EMD). Other sources were also reviewed.

The mining/smelting operation produces three types of contaminants which may be discharged into the environment: sulfur dioxide, heavy metal particulates and tailings. Emission of sulfur dioxide from the smelter was modified in 1974 when a 250 m stack was built to replace two shorter stacks. From that time pollutants have been discharged from a higher altitude resulting in a greater area of dispersion and a reduction of in-town sulfur dioxide pollution. In addition, a new electrostatic precipitator installed in 1982 reduced the emission of particulates.

Tailings, containing waste rock and water including various chemicals is discharged to the tailings pond west of HBM&S. Solids are settled out and stored. Winter freezing dries the surface of the stored solids leaving a powder which can be picked up by winds and distributed over the area. Liquid effluent, bearing heavy metals not extracted in the treatment process, is discharged from the tailings pond into Flin Flon Creek which is connected to the Ross Lake and Schist Lake water system.

In 1981, CEC limited the stack emission to 885 tons of sulfur dioxide and 6 tons of particulate matter per day. By this order, the stack emissions must be reported by mass balance calculations on a monthly basis and once a year by stack sampling. Although the estimates of emissions by mass balance calculations differ from those by stack sampling, the availabe information shows that the daily limit for sulfur sulfur dioxide was not exceeded between 1975 and 1985. Similarly, the 5 year average emissions of sulfur dioxide between 1950 and 1975 did not exceed the 885 tons per day limit. However, the emissions of sulfur dioxide between 1950 and 1984 were never lower than 80 percent of the current CEC limit. Between 1983 and 1985, the

emission of particulates was between 6 and 15 tons per day. Although higher than the limit permitted by CEC, these emissions were much lower than before 1983 when they were between 40 and 45 tons per day.

Between 1973 and 1983, the ambient sulfur dioxide levels were higher in Flin Flon than in residential areas of Winnipeg. Since 1974, both the ambient sulfur dioxide level and the frequency of sulfur dioxide excursions above the one hour average maximum acceptable level (0.34 parts per million or 0.9 mg/m^3 of air) decreased although the quantity of sulfur dioxide discharged through the stack did not change. At the present time, the maximum acceptable levels are still frequently exceeded.

Data on heavy metal concentration in the air obtained by high-volume sampling is scarce. The available data indicated that the level of total suspended particulates was below the provincial objective. It was also lower than in Winnipeg. While zinc was not measured, the copper concentration was six times higher in Flin Flon than in Winnipeg and the concentration of iron was similar in both locations. While low concentrations of cadmium and arsenic were reported in Flin Flon, these elements were below the detectable level in Winnipeg. Lead concentration in Winnipeg was slightly higher than in Flin Flon.

Sulfur dioxide is monitored continuously by 5 monitoring stations, 3 of which are operated by HBM&S and two by EMD. Special studies have been carried out to determine the accumulation of heavy metals in soil, snow, vegetation, tissue of small mammals, fish flesh as well as the metal content of water and sediment from surface waters in the area.

Snow studies carried out have demonstrated that the deposition of heavy metals decreased with the distance from the smelter. Copper, lead, iron, cadmium, zinc and arsenic have been shown to be present in snow columns as the result of aerial deposition. The loadings decreased after the new precipitator had been installed in 1982. An increase in the loadings observed in 1984 and 1985, was attributed to a reduced efficiency for the electrostatic precipitation of particulates.

Analysis of soil has indicated that the highest concentration of zinc is near the smelter. This concentration decreased to background levels approximately 30 km away from the smelter.

In vegetation studies, there was no effect on abundance of shrubs and trees more than 5 km from the smelter. The abundance of lichen and mosses was reduced in the vicinity of the smelter in comparison with areas away from the smelter. The concentration of metals (lead, copper, zinc, cadmium, iron) in jack pine cones and the accumulation of lead and mercury in blueberries decreased with the increasing distance from the smelter.

Small animals (deer mice) were trapped at different distances from the smelter. The highest hemoglobin levels, although still within

physiological limits, were found in deer mice trapped near the smelter and the lowest, or background levels, in animals trapped about 40 km from the smelter. Copper, arsenic and lead accumulated in small mammals and their concentration in the tissue of small mammals decreased with the increasing distance from the smelter.

The effluent from the HBM&S tailings pond, containing heavy metals, enters Ross Lake via Flin Flon Creek and eventually reaches the Schist Lake system. Ross Lake is nearly devoid of fish while the benthic organisms are sparse and their diversity is low. The deterioration of the water in Schist Lake was greater than expected if only aerial deposition of heavy metals occurred.

It appears that fish in the lakes impacted by aerial deposition of heavy metals could be adversely affected particularly with respect to reproduction and growth. Production of metal binding proteins may to some extent protect fish from the toxic effect of metals in their environment. Elevated levels for zinc, mercury, selenium, cadmium, arsenic, and copper in the lakes increased the probability of accumulation of these elements in the fish tissue.

Although elevated, concentrations of metals in the water column were within guidelines required for drinking water. With respect to the microbiological quality of drinking water in Flin Flon, high Standard Plate Counts (SPC's) were found. It is not clear, however, if high SPC's were due to high natural occurrence of micro-organisms in water, to contamination, to an inadequate treatment of drinking water or to problems arising from the transportation of water samples to the Cadham Provincial Laboratory in Winnipeg for analysis.

Occupational Exposures in HBM&S

The results of industrial hygiene surveys and monitoring carried out by HBM&S, Labour Canada and the Workplace Safety and Health Division including the Mines Branch were reviewed in order to describe the exposures occurring in HBM&S by areas and by jobs.

The HBM&S operation in Flin Flon includes mining and smelting of copper, zinc, lead, cadmium, gold, silver, selenium and tellurium. Worker exposures vary depending on the specific tasks required by each job description.

Results of underground industrial hygiene monitoring showed that the exposure of workers to dusts including silica and fumes was due to drilling, blasting and handling of ore. Job categories involved in drilling, blasting and handling of the ore had higher dust exposures than jobs referred to as support services. Exposure to Diesel fumes in Flin Flon mines did not occur until the 1970's when Diesel scooptrams began to replace the electric locomotives. Underground exposures to workers were poorly documented. Available data showed, however, that

most measurements of respirable dust were below the threshold limit value (TLV).

HBM&S surface workers experienced a different exposure profile than those underground. High levels of respirable dust, particularly of silica dust, were measured in areas where ore was crushed and milled. This problem was alleviated by the construction of isolation booths at some locations in the 1970's.

After leaving the mill, all concentrate is roasted before further processing. The elevated temperatures required to reduce the concentration of sulfur in the concentrate change the exposure of workers. This is reflected in the increased concentrations in the work environment of sulfur dioxide and fumes containing primarily zinc, arsenic, copper, cadmium and lead along with other elements. Concentrations of contaminants were the highest in the feeder and gear floors of the roasters, ie. on the top and bottom of the roasters. After leaving the roaster, zinc concentrate is leached, plated and then cast into ingots. The result of the wet acid process for leaching and plating is a minimal dust concentration and an increased concentration of acid mist in the air. In addition, the leaching process may be responsible for exposure to cyanide gasses. Zinc casting is the final operation of the zinc process and involves melting of zinc plates.

The new zinc casting plant was constructed in the 1980's. The industrial hygiene monitoring data showed a higher proportion of zinc in total dust than in other areas. While the current levels are not above TLV there is some indication that exposures in the old plant were much higher.

The copper process involves further separation of the metals by smelting. In the smelter area, most of the gasses produced are collected by an indirect control (scavenger) system. Because the technological process is not enclosed, contaminants enter the workplace whenever the output of gasses exceeds the capacity of the control (scavenger) system or the process equipment is not connected to the central system. Although the discharge of contaminants into the work environment has decreased with the introduction and improvement of environmental control systems, exposure of workers continues to be a problem in the areas where the reverberatory furnace, converters, and fuming furnaces are located. In these areas the concentration of contaminants was high for sulfur dioxide and total dust containing zinc, copper, cadmium and arsenic.

It was difficult to assess the type of exposure for some occupations because either there were no data collected or the duties performed by the worker may result in a continuous change of work areas. The example for the former group are the rubber workers and for the latter group are general maintenance duties such as painters and riggers.

The industrial hygiene monitoring data, although incomplete and covering only the most recent period, provided a valuable source of

information on exposure of workers, particularly with respect to the type of exposures that may be associated with some jobs.

Although the exposures of workers have been reduced over time, continued excessive exposures were well documented for some areas and jobs. The summary of exposure data based on measurements obtained from HBM&S, Workplace Safety and Health Division and Labour Canada had identified the highest combined exposures in the areas of zinc and copper roasters, bedding bins and in the smelter.

The existence of high exposures in some areas of the plant was reported by the Labour Canada industrial hygiene survey. This survey was carried out in May, June and September 1983 and January 1984. Results indicated that 30 percent (26 out of 86) of total dust measurements in the zinc roaster area exceeded the TLV (American Conference of Governmental Industrial Hygienists, 1983-84) of 5 mg/m^3. The proportion of total dust measurements above TLV for the zinc casting area was 10.3 percent (2 out of 29), the reverberatory furnace area 16.6 percent (2 out of 12), the bedding bins area 27.3 percent (3 out of 11), and the fuming plant 12.0 percent (3 out of 25). In these areas, the TLV concentration for zinc was exceeded 3 times (in zinc roaster area and fuming plant), copper 4 times (zinc roaster and reverberatory furnace area), lead 9 times (zinc roaster area and fuming plant), cadmium 2 times (cadmium casting) and arsenic once in the zinc roaster area. Total dust concentration did not exceed the TLV in the copper roaster area (0 out of 16).

The TLV level for sulfur dioxide (5 mg/m^3) was exceeded in 70.7 percent of samples taken in the zinc roaster area (70 out of 99), and in all samples taken in the reverberatory furnace (14 out of 14) and copper roaster areas (4 out of 4).

The concentration of respirable dust exceeded the TLV in 75 percent (15 out of 20) of samples taken in the crusher area. The concentration of sulfuric acid in the electrolytic tankhouse was higher than the TLV of 1 mg/m^3 in 37.2 percent (19 out of 51) of samples taken.

Mortality in Flin Flon, Manitoba, 1959-83

Using the National Mortality Database of Statistics Canada, an analysis of the mortality pattern in Flin Flon between 1959 and 1983 was carried out. This mortality pattern was compared with Manitoba as a whole and with five communities in Manitoba (Brandon, Dauphin, The Pas, Steinbach, Portage la Prairie) and one in Saskatchewan (Creighton).

Results of the analysis suggested that, during this period, the mortality of males in Flin Flon was significantly above the provincial average for all causes, all cancers, cancer of the trachea, bronchus and lung, chronic obstructive pulmonary disease (COPD) and accidents. In females, only mortality due to all respiratory diseases was significantly elevated. However, for the period between 1974 and 1983, the excess of mortality from all causes was significant for both sexes.

In addition to being above the provincial average, mortality for selected causes in Flin Flon was higher than in most of the five similar size comparison communities in the province (The Pas, Dauphin, Portage la Prairie, Brandon, Steinbach).

The mortality due to accidents was significantly elevated in Flin Flon males but not in females. If the deaths attributed to accidents (26 in number) are subtracted from the observed deaths for males in Flin Flon, there is still an excess of mortality from all causes although the standard mortality ratio (SMR) diminishes from 1.09 to 1.06. The excess in mortality from all causes for either males or females cannot be explained by accident caused deaths alone.

Cancers contributed to excess mortality in both sexes, although the SMR for all cancers was significantly elevated only in males. Over the 25 year period, there were 34 excess cancer deaths in men or 1.4 per year. Most of these were due to cancers of the digestive tract (13 in number) and cancer of the trachea, bronchus, and lung (16 in number). This excess was not uniformly distributed over time. Data suggested that the excess of digestive tract cancers was higher prior to 1964 than after.

Respiratory diseases contributed to the excess deaths in both sexes although significantly only in females. The excess of deaths due to COPD was significant in males, but not in females.

Mapping of Cancer Incidence in Manitoba by Geographic Locale: Results for Flin Flon

The Department of Epidemiology and Biostatistics of the Manitoba Cancer Treatment and Research Foundation is systematically studying the incidence of specific cancer sites according to the geographic locale such as census division, municipalities and towns. Comparison of the City of Flin Flon with Manitoba for the period 1965-79 was made available for this report.

The incidence of cancers for Flin Flon as recorded by the Provincial Cancer Registry is available for three periods: 1965-69, 1970-74 and 1975-79. In the first period, significantly (P 0.05) fewer cancers were registered than expected for both males (15 observed in comparison with 61.6 expected, Relative Risk, RR = 0.24) and females (20 vs. 54.6, RR = 0.37). Between 1970 and 1974, there was an excess of cancers in males (85 observed vs. 73.8 expected, RR = 1.5, not significant) but not in females (59 vs. 60.5, RR = 0.97). Between 1975 and 1979 there was an excess in both males (101 vs. 83.2, RR = 1.21, significant) and females (73 vs. 69, RR = 1.06, not significant).

The observed number of cases significantly exceeded the expected number of cases for cancer of the larynx (1970-74), cancer of the prostate (1970-74), cancer of the trachea, bronchus and lung (1975-79) in males, and for cancer of the larynx (1975-79) in females.

The results should be interpreted cautiously. Low risk ratios in the earliest period, 1965-69, could be due to an incomplete registration of cancers in Flin Flon in comparison with the province. Risk estimates could also be biased by the migration pattern of the population and by lack of precision in recording the residence of cancer cases.

Morbidity in Flin Flon

The Manitoba Health Services Commission (MHSC) administers the Manitoba Health Insurance plan. Virtually all health services used by residents of the province are recorded and paid for the MHSC. The exception are those health services which are the responsibility of the Workers Compensation Board. Since the reason (diagnosis) for using health services is coded on physicians claims for payment, these could be used to determine the utilization rate of health services for various diseases or groups of diseases. The proportion of people who use medical services for a specific disease (i.e. utilization rate) during a specified period of time is an estimate of the period prevalence.

MHSC records were used to determine the period prevalence for various groups of diseases for the residents of Flin Flon as well as for the province as a whole. The aim of this investigation was to determine if for any of the broad disease categories, health services were used more by Flin Flon residents than by the provincial population.

The comparison of Flin Flon utilization rates with those for the province suggested higher morbidity in Flin Flon in all age groups due to injuries and diseases of the respiratory, digestive and musculoskeletal system including connective tissue. In addition, the morbidity due to diseases of the genitourinary system and congenital anomalies were higher in the age group 0-4 years.

On the other hand, the utilization rates of medical services for endocrine, metabolic diseases and immunity disorders, disease of blood and blood-forming organs and for mental disorders were lower than the provincial rate. Infectious and parasitic diseases, neoplasms, diseases of the nervous system and sense organs, circulatory system, genitourinary system (5+ years), and disease of skin were not different from the provincial average.

Occupational Lung Disease Surveillance of HBM&S Employees

Results of medical examinations of HBM&S workers were reviewed to determine the prevalence of radiographic abnormalities consistent with pneumoconiosis, the prevalence of the obstructive pattern of lung function and the prevalence of smoking habit. These tests were conducted under the Occupational Lung Disease Surveillance program in order to comply with the Regulation 209/77. They were carried out between 1976 and 1983.

Results of annual examinations of the HBM&S employees show that while there were cases of pneumoconioses (silicosis and asbestosis) diagnosed, the number was relatively low between 1976 and 1984.

Radiographic abnormalities which were suspect of pneumoconiosis (silicosis and asbestosis) were diagnosed in 25 (5.7 per 1,000) workers. Data on the occurence of pneumoconioses amongst HBM&S workers prior to 1976 was not available and therefore it could not be concluded if the prevalence between 1976-84 represented a reduction of this disorder.

Lung function testing indicated that chronic airflow obstruction was a common disorder, affecting up to 25 percent of HBM&S employees. It was not clear to what extent this disorder could be ascribed to occupational factors or factors in the general environment in addition to smoking which is its most important cause in the general population. It should be pointed out that smoking was very common among the employees of HBM&S. On annual surveys, approximately 50 percent of workers were classified as smokers.

Feasibility Study of Death Certificates

The death certificates of all residents of Flin Flon who died between 1952 and 1984 were identified and studied in order to determine the primary (underlying) and secondary causes of death. In addition, the feasibility of using the HBM&S records for constructing the occupational histories for individuals who had been employed for any length of time by the company was examined.

Approximately 70 percent of male residents of Flin Flon who died at the age of 20 years or older between 1952 and 1984 had been employed by HBM&S. Only 85 percent of these men had a mining or smelting job listed as an occupation on their death certificate. This indicates that job codes on death certificates were not an adequate indicator of past exposures in the mining/smelting industry. On the other hand, a mining job was listed under occupation on the death certificate for 15 percent of the men without record of employment at HBM&S. It is possible that some residents of Flin Flon worked in the mining/smelting industry but not at HBM&S.

In addition to the primary (underlying) cause of death, a number of secondary causes were identified. Cancer was rare among secondary causes. Disease such as COPD and diabetes were more frequently listed as the secondary than as the primary cause of death.

A greater proportion of residents with history of HBM&S employment died of cancer than of those without HBM&S employement. This was apparent particularly for cancer of the trachea, bronchus and lung and for cancer of the large intestine including rectum.

At death, Flin Flon residents with HBM&S work experience were younger than residents without a history of HBM&S employment. The duration of employment was relatively long. Only 12 percent of individuals who were employed by HBM&S were employed for less than 5 years.

The distribution of occupational exposure groups was not uniform between workers who died of difference causes.

Discussion

Conversations with union leaders, workers at HBM&S, and residents of Flin Flon indicated that people were concerned about the effects that the mining and smelting operation might have on the health of those who work inside HBM&S and those who live in the vicinity of the operation. Opinions ranged from none or little concern to extreme concern.

There is reason for this concern. Flin Flon was founded next to the metallurgical complex. The community has been expanding according to the needs of the industry for more than fifty years and remains a single industry town. Many who came looking for work decided to establish themselves permanently in the community. The fact that there are families with three generations in Flin Flon demonstrates the attachment of the population to the city and its environment. The proportion of individuals over 65 years of age increased from 1.1 percent in 1956 to 6.1 percent of the total population in 1981.

The present situation is the result of historical development. At the present time, Flin Flon is a community of approximately 8,000 people who live beside the fourth largest mining and metallurgical complex in the country (and one of two in the province). During the 1970's people were becoming increasingly aware of health hazards at work as well as risks that industrial emissions might represent for the communities in which the industry was located. This awareness hightened when health hazards in copper smelters and neighbouring towns, similar to the situation in Flin Flon, were recently publicized. In view of this, it is not surprising that Flin Flon residents are concerned about their health and environment.

One purpose of this investigation was to examine the evidence for health hazards in the working and general environments of Flin Flon. Another was to review the evidence that these hazards might be producing adverse effects on health of the Flin Flon population. The investigation was limited to the examination of available data.

There are only fragmentary data on exposures in either the work or general environment before 1970 and few measurements were obtained between 1970 and 1974. Since 1974, exposures in the general environment and in the HBM&S working environment have been measured.

However, these measurements cannot be generalized to the period before 1974 without caution. Exposures before 1974 are suspected to have been higher because of improved controls in the occupational and general environmental conditions over the last ten years.

The review of the general environment data indicated that HBM&S is a major source of environmental pollution in Flin Flon. There are direct emissions of sulfur dioxide and particulate matter containing heavy metals into the air primarily through the HBM&S stack. These emissions could eventually produce loadings of surface waters and of soil. In

addition, waste from HBM&S is discharged via the tailing pond into the surface water system.

The sulfur dioxide emissions have been dispersed over a larger area since 1974 when the 250 meter stack was built. The emission of particulates has been reduced since 1982 when the new precipitator was installed. These two modifications of the plant resulted in lower levels of pollution in Flin Flon.

The effects of emissions produced by HBM&S are seen in vegetation, small animals (mammals) and fish in the area within 40 km of the smelter. The reduction of emissions resulted in a documented reduction of these effects.

The HBM&S work environment is very complex as it involves mining, smelting and refining of metals and, in addition, a variety of supporting jobs. It should be pointed out, that some areas of the industry are, with respects to the working environment, technologically old. Although technological changes resulted in reduced exposures and presumably reduced health risks for workers, high exposures remain in some areas. In some instances, contaminants or combinations of contaminants affect only small numbers of workers. There are, however, contaminants to which a large number of workers are exposed.

Several sources of morbidity and mortality data were reviewed to determine if there was evidence that some diseases or health effects occurred more frequently in the population of Flin Flon than in the rest of the province. Most of these sources are "soft" and possible biases could not be properly controlled. Since the results of the analyses of data from the National Mortality Database, Cancer Registry or Manitoba Health Services Commission could be affected by migration pattern of the population or by other factors such as ethnic origin, etc., they should be interpreted cautiously.

An increased occurrence of some health problems in Flin Flon, particularly of cancers, respiratory diseases and injuries/accidents, was suggested by the mortality statistics, Cancer Registry data and morbidity/medical services utilization data.

Analysis of the mortality pattern between 1959 and 1983 showed that in comparison with the provincial average, male residents of Flin Flon were more likely to die of all cancers, cancer of the trachea, bronchi and lung, COPD or because of an accident. Female residents were more likely to die from respiratory diseases. Mortality in Flin Flon was also higher than in most of the five similar size communities in Manitoba (The Pas, Dauphin, Portage la Prairie, Brandon, Steinbach). Cancer mortality data were consistent with Cancer Registry data indicating Flin Flon has an elevated incidence of all cancers (1970-79), cancer of the larynx (1970-74), cancer of the prostate (1970-74) and cancer of the trachea, bronchus and lung (1975-79) for males and cancer of the larynx for females (1975-79). For all ages,

the utilization rate between 1981 and 1984 was higher in Flin Flon than in the province for diseases of the respiratory, digestive, and musculoskeletal system and for injuries. For the age group 0-4 the utilization rate was higher for the genitourinary system and for congenital anomalies.

Although the medical services utilization rates suggested an increased rate of congenital anomalies in Flin Flon, this was not confirmed by data obtained from the Manitoba Congenital Anomalies Registry (Manitoba Health, Becker, personal communication). In 1981, congenital anomalies were reported for 7 newborn babies out of 151 total live and stillbirths in Flin Flon (rate 46.3 per 1,000). In 1982, 6 cases were reported in Flin Flon (44.1 per 1,000 in comparison with the provincial rate of 67.9 per 1,000) and in 1983 10 cases (66.7 per 1,000 in comparison with 66.5 per 1,000 for the province). In 1984, there were also 10 cases reported for Flin Flon. The provincial rate could not be estimated because the total number of births was not available.

None of our sources of mortality or morbidity provided any evidence that there was an increased risk of ischemic heart disease in the Flin Flon population.

The increased occurrence of cancers, COPD and other respiratory diseases, and injuries in Flin Flon could be due to a variety of causes. Smoking is the foremost causal factor to be considered for cancer of trachea, bronchi and lung and COPD. Unfortunately, data are not available to examine if differences between Flin Flon and the province, and Flin Flon and other communities could be explained by differences in smoking alone.

Data were examined to determine if there was any evidence that an elevated occurence of these diseases could be due to either factors in the general environment of flin Flon or to factors in the HBM&S working environment. Three subsets of the Flin Flon population, males, females and children, might provide some answers to this question. It is difficult to interprete data from males because the majority of males in Flin Flon were at one point in time employed by HBM&S or were occupationally exposed to the mining/smelting industry elsewhere.

Females are a good source of information about the effects of the factors in the general environment since only a small number were exposed to the HBM&S working environment. Health effects in females could be explained by either residential exposures or by lifestyle or by a combination of both. Our data show that with few exceptions, female mortality in Flin Flon was not elevated in comparison with the province as a whole or with females in five other communities. The mortality data for females do not support the hypothesis that the general environment exposures present an excessive risk for health of residents in Flin Flon.

Children could also be a good source of information about the effects of the general environment. Unfortunately, we do not have good markers of environmental health effects for children except congenital anomalies. Data do not suggest a relationship between the incidence of congenital anomalies and the general environment.

In the absence of more sensitive measurements of health, observations on females and children are not consistent with the hypothesis that factors in the general environment increased the risk of disease and death in Flin Flon.

The fact that the excess mortality due to cancer and COPD was found in males and not in females, suggests the possibility that occupational factors might be important for this excess. In the industrial environment exposures to excess concentration of some contaminants where found.

There is further evidence that occupational factors might be important for the development of certain cancers and COPD.

The evidence for cancer is the following. First, among those who died in Flin Flon between 1952 and 1984, the proportion of deaths attributed to cancer (all cancers, cancer of the trachea, bronchi, lung) was greater among those deceased residents of Flin Flon with history of HBM&S employment than among those who had never been employed by HBM&S. Second, the occupational histories of HBM&S employees who died from cancer (all cancers and cancer of the trachea, bronchi and lung) differed from occupational histories of those HBM&S employees who died from other causes, suggesting a different type of exposure.

The evidence for COPD is forthcoming from a study entitled "Occupational factors in the etiology of chronic bronchitis and chronic airflow obstruction". In this study, lung function changes between 1976-77 and 1983 were determined for 972 employees of HBM&S. These workers were employed continuously between 1976-77 and 1983 and were tested at least four times during this period. Changes in lung function were assessed as the average change in the forced expiratory volume in one second (FEV_1) per year. FEV_1 is an index of chronic airflow obstruction and of COPD. Smoking habits were obtained by a questionnaire administered as part of the examination. Occupational histories were compiled using HBM&S employment records. Results of the analysis show that FEV_1 deteriorated more in those who smoked during the study period than among those who stopped smoking before the beginning of the study (in 1976) or those who never smoked. In addition, there were significant differences in change of FEV_1 between different exposure groups after differences between exposure groups in age, smoking habits and FEV_1 at the beginning of the study had been taken into account. The FEV_1 decline was greater in those exposure groups which were characterized by high concentrations of sulfur dioxide and total dust (roaster and smelter area), sulfuric acid (electrolytic tankhouse) than in those in surface department with lower

exposures or underground where the levels of respirable dust were estimated at approximately one-third of the TLV.

Although it is possible that factors in the general environment were responsible for some of the excess morbidity and mortality in Flin Flon, it is more likely on the basis of the analysis of the available data, that this excess was due, at least to some extent, to factors in the working, industrial environment of HBM&S.

The failure to show a relationship between the general environment and health could be due to several reasons. Methods used to assess health effects in the population due to the environment might not be sufficiently sensitive. On the other hand, the exposure and associated risks in the general environment might be too low to be detected in a relatively small population (i.e. less than 10,000). It is also possible that the combination of insensitive methods to determine health effects, relatively low risks and a small population is responsible for this failure.

While data suggest that the industrial environmental factors at HBM&S are a possible explanation for the excess of certain cancers and COPD in Flin Flon, it should be emphasized that the evidence is not definitive. Definitive answers are not possible on the basis of data presently available. The present data cover only a subset of HBM&S employees, i.e. those who were residents of Flin Flon. It would be misleading to overinterpret the presently available data.

If the information about the relationship between the HBM&S industrial environment and health is desired, an epidemiological study is necessary in which the morbidity and mortality would be related to occupational exposures. The basis for such a study would be the establishment of a population at risk, i.e. those who have been, for any period of time, employed by HBM&S. In such a study, the role of smoking would also have to be addressed.

The feasibility for a such a study was examined. It was concluded that it is possible, due to good record keeping of HBM&S, to assemble a cohort of HBM&S workers employed since the beginning of mining and smelting in Flin Flon. A portion of this cohort (those employed since 1970) are already assembled for the purpose of the "Occupational Lung Disease Surveillance" program. It was also established that it is possible to compile a satisfactory working history for each employee of HBM&S. It was also possible to reach a consensus with representatives of both the management and the unions of HBM&S about grouping job titles into occupational exposure groups.

There are established ways to ascertain the vital and morbidity status of the members of the occupational study group. Follow up by the National Mortality Database with its available linkage methodology could be combined with local sources of information such as MHSC, the Cancer Registry, and the "Occupational Lung Disease Surveillance" program.

The role of smoking could be assessed in a case-referent study, nested in a cohort study. Although some information on smoking habits will need to be collected, it should be remembered that a large quantity of information on smoking is already available for the "Occupational Lung Disease Surveillance" program.

On the basis of this report it is concluded that a study, if desired and agreed upon by both the management and the unions of HBM&S, is feasible.

CONCLUSIONS

1. Residents of Flin Flon and employees of HBM&S have a wide range of concerns about possible health effects due to occupational and general environmental exposures caused by HBM&S operations.

2. Industrial emissions and discharges, particularly sulfur dioxide and heavy metals, pollute the air, surface waters and soil in Flin Flon and surrounding area. The levels of in-town pollution with sulfur dioxide have been reduced since 1974 when the 250 m stack was constructed and those of heavy metals since 1982 when the electrostatic precipitator was installed. The emissions and levels of pollution in the City of Flin Flon and in the surrounding area should continue to be monitored in a systematic manner.

3. Effects of discharges from the industry are detected in small animals and vegetation in the area up to 40 km from the HBM&S complex.

4. The industrial environment of HBM&S is very complex with large numbers of workers exposed to some contaminants or their combinations. Underground, the predominant contaminants are respirable dust containing silica and fumes resulting from operating Diesel equipment and blasting. In the smelter and in most of the zinc plant, the predominant contaminants are sulphur dioxide and metal fumes (total dust) containing zinc, copper, lead, cadmium, and arsenic. Sulfuric acid is present in the electrolytic tankhouse. Technological changes have reduced some exposures over time. Continued high exposures, even above TLV levels, are well documented for some areas and some jobs. Exposure of workers should continue to be monitored. For some groups of workers (for example underground employees and those who regularly change the area of work), exposure is poorly documented and steps should be undertaken to obtain adequate estimates of their exposure.

5. Adequate estimates of exposures prevailing in the general and in the working environment are essential for evaluation of the impact of technological development on these levels and of the impact on these levels on vegetation, animals and humans living in the contaminated environment.

6. Review of available mortality data suggests statistically a significant excess of cancers, chronic obstructive lung disease and injuries in the male population of Flin Flon. The available morbidity data are consistent with findings of the mortality analysis.

7. The industrial environment of HBM&S is more likely responsible for this excess of morbidity and mortality than the exposures in the general Flin Flon environment. Some of the excess could be due to smoking.

8. The presently available data are insufficient to evaluate in a definitive manner the role of occupational exposures for the development and for the excess of cancers and respiratory disorders.

9. An epidemiological study of the working population of HBM&S could resolve the question if there is a relationship between the occupational exposures and the development of diseases.

10. An epidemiological historical cohort study to determine risks associated with job exposure is feasible. It is possible to identify the population at risk. It was demonstrated that it is possible to determine the types of exposures, and compile working histories for all those employed by HBM&S since the beginning of the operation in Flin Flon. The follow up methodology to ascertain causes of death is also available.

CHAPTER I

PUBLIC PERCEPTIONS OF HEALTH PROBLEMS IN FLIN FLON

TABLE OF CONTENT

	Page
INTRODUCTION	1
OBJECTIVES	1
INTERVIEWS	1
INTERVIEWS WITH FLIN FLON RESIDENTS	2
HEALTH CONCERNS	2
WORK ENVIRONMENT CONCERNS	3
GENERAL ENVIRONMENT CONCERNS	4
OTHER CONCERNS	5
ATTITUDES TRANSMITTED	6
INTERVIEWS WITH UNION LEADERS	6
TRADE UNIONS	6
STEELWORKERS	8
PUBLIC MEDIA	8
SUMMARY	9
APPENDIX	

INTRODUCTION

Flin Flon is a relatively small, single industry community in Northern Manitoba. For some time there has been concern about possible health risks associated with working inside Hudson Bay Mining and Smelting Company (HBM&S) or residing in its neighborhood.

In this part of the study an attempt was made to determine how these risks or health problems were perceived by the residents of Flin Flon and employees of HBM&S. We hoped to achieve this by talking to selected residents of Flin Flon rather than to use a survey of a representative sample of the Flin Flon population. A summer student, Shari Pierangeli, was asked to talk to as many residents of Flin Flon as possible and to representatives of the HBM&S Unions about their opinions of the health aspects of living in Flin Flon or working for HBM&S. She was then asked to summarize these conversations into a report. Since public perceptions of the problems were expected to be reflected by the local media, she was also asked to review what the local media had written about Flin Flon, HBM&S and health hazards.

Over one summer, Shari Pierangeli talked to 53 residents of Flin Flon and 15 representatives of the following HBM&S Unions:

United Steelworkers of America, Local 7406;
Association of Flin Flon Trade Unions;
International Association of Machinists and Aerospace Workers, Local 1848;
International Brotherhood of Electrical Workers, Local 1405;
International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers, Local 451;
United Brotherhood of Carpenters and Joiners of America, Local 1614;
Brotherhood of Painters and Allied Trades, Local 1497;
International Union of Operating Engineers, Local 828;
International Brotherhood of Electrical Workers, Local 1598.

The following is her report:

OBJECTIVES

The objectives of the interviews were to obtain information on:

- opinions and concerns about the effects on health of the HBM&S workplace environment and the general Flin Flon environment;

- major health problems as perceived by Flin Flon residents and employees of HBM&S.

INTERVIEWS

Interviews were conducted as informal conversations during which the following questions were asked:

- Do you have any concerns about how the workplace environment at HBM&S affects the health of employees? Where? What are the dangers?

- Do you have any concerns about how the general Flin Flon environment affects the health of residents? What are the dangers?

- What do you perceive as the major health problem in Flin Flon? Secondary?

- Do you have any evidence or specific examples to support your opinions? Explain.

- Do you have other concerns, directly or indirectly related to the health of Flin Flon residents?

- Do you know anybody else who might like to speak to me or who might provide me with useful information?

INTERVIEWS WITH FLIN FLON RESIDENTS

HEALTH CONCERNS

Respiratory Problems

Respiratory problems were the most commonly mentioned ailment. Over two thirds of the interviewees discussed major respiratory problems which included emphysema, asthma, bronchitis, silicosis and other diseases. Less severe problems such as allergies, sinuses, colds, and coughs were mentioned by even more interviewees. Most interviewees felt that the work environment at HBM&S was a major contributing factor, perhaps even the cause of the illnesses. A few felt that the general Flin Flon environment was a major factor for respiratory problems of non-HBM&S employees. Other contributing factors mentioned were smoking, war experiences (gas), and weather.

Cancer

Cancer was the second most common concern and was discussed in over half of the interviews. It was felt that cancer seemed to be appearing more frequently in the younger population of Flin Flon. Most often cancer was referred to in a general manner, and included all types. Most of the interviewees could not make a direct connection between the cause of cancer and the illness itself. Some felt that the environment was one of many factors. Other factors mentioned were diet, exercise, smoking, stress, food preservatives, chemicals used on growing food, sun, and genetic defects. Some stated that they felt their work environment at HBM&S was directly responsible for their cancer.

Heart Problems

The third most commonly mentioned illness was heart problem, and in particular heart failure. About one third of the interviewees discussed this during the interview. The majority of interviewees who mentioned heart problems considered many factors to be the cause. Of these the most prevalent one was stress. According to the interviewees, the two major causes of stress were war, and the hard fast lifestyle in Flin Flon. They found it difficult to directly relate heart failure to the local environment, although they felt that the environment may be one of many contributing factors.

Others

Other illnesses mentioned to a lesser degree than cancer, heart problems, and respiratory problems were: lead poisoning, nerve disorders, arsenic poisoning, mental disorders, colitis, asbestosis, circulatory problems, ear infections, deafness, and ulcers.

In this group, lead poisoning and asbestosis were the most frequently mentioned occupational diseases.

WORK ENVIRONMENT CONCERNS

Smelter

Several interviewees either had experience in the smelter or had heard much about it. Virtually all the interviewees claimed that it was inhumane to work in such an environment. They claimed that some of the gasses and fumes were certain to affect employees' health.

Zinc Plant - Tankhouse

The acidic air in the tankhouse was a major concern since "if the air eats away your teeth and clothes, just think of what it does to your insides when you breathe it in for extended periods of time". Presently, the employees wear cloth masks which are helpful but legislation may soon force them to wear approved respirators. This was a factor which concerned the workers because of the perceived problems with wearing rubber face masks.

Mines

Following the smelter and tankhouse, interviewees were most concerned about working underground. In mines the dust and diesel fumes were thought to be the most harmful. Many who had worked in the mine had mentioned respiratory problems. In addition, almost all suffered from hearing loss.

Crusher

In the crushing area the dust was the major concern. It was thought to be most harmful to those who do not wear masks.

Assay Lab

Chemicals used to digest samples were thought to produce dangerous gasses. Some interviewees felt that because of poor ventilation in the lab, workers were inhaling these gasses and were at risk of developing diseases from exposure.

Other Work-Areas or Occupational Concerns:

Fuming Plant because of fumes and gasses.

Painters because of fumes from paint thinners.

Machine shop and especially welders because of fumes.

Asbestos

Some interviewees mentioned "asbestos fights" which they had had with their fellow employees (horse play). Asbestos was commonly used as an insulator for walls and furnaces. However, most interviewees agreed that the awareness of the dangers of asbestos had increased tremendously and measures were being taken to improve the situation.

GENERAL ENVIRONMENT CONCERNS

Almost all of those interviewed compared the general Flin Flon environment before and after the tall stack was constructed. The interviewees felt that that change was tremendous and that Flin Flon is now relatively ideal. Most realized that the tall stack had not eliminated the problem but it had at least passed most of the harmful emissions over the immediate Flin Flon area which was their greatest concern.

A portion of those who lived in the City before the tall stack was built, viewed the emissions more as a bother than anything else. They felt that it had probably harmed them to some degree but it was hard to know just how much. They saw the foliage rejuvenating around them after the construction of the tall stack and felt that they too must be rejuvenating and will consequently not experience long lasting health effects.

This viewpoint was not shared by all interviewees. Some, especially the uptown residents, felt that the concentrated emissions falling on Flin Flon before the tall stack was built, affected citizens' health to a fair extent with probable long lasting effects.

In addition, the following concerns were expressed by interviewees in response to questions about the environment of the Flin Flon area:

- acid rain and its effects on the lakes and fish in the area;

- water pollution by heavy metals constituents from smelter emissions (especially on Phantom Lake, Hapnot Lake, Ross Lake, Trout Lake, Douglas Lake, and Schist Lake);

- the effect of spent oil with PCBs from HBM&S which was once used used to suppress dust on gravel roads in Flin Flon. (In addition, employees reported taking it home for personal use. Increasingly, more people are aware of the effects of PCBs although such practices were stopped 5 years ago);

- dust from the tailings pond worried a few interviewees although they they were unsure of how much it adversely affected their health. (One interviewee stated that "it certainly cannot be good for people". Most of those concerned citizens were from Uptown or Creighton);

- heavy metals in gardens and lakes. This concern was mentioned a couple of times and was accompanied by a desire that tests be conducted in this area.

There was unanimity amoung the interviewees that drinking water in Flin Flon tastes better than anywhere else.

OTHER CONCERNS

Interviewees reported the following other concerns associated with living in Flin Flon:

- Psychological effects from living in a mining town were noted. The single industry town produces a fast, hard lifestyle. Hard work, drinking and drugs were believed to be important components of life in Flin Flon. The latter two were believed to be the cause of many illnesses as well as accidental deaths. In addition, it was felt that there was a great deal of stress produced by shiftwork and worry about the town closing down.

- A feeling about the lack of proper medical services was also evident. Many interviewees felt that the doctors were not providing quality medical services. In addition, adequate medical facilities were said to be lacking.

- Weather was another concern of some interviewees, including a doctor. The winters are harsh, and unlike Florida where a cold may linger for up to 2 days, in Flin Flon it lasts for at least one month. Doctors suggested that this harsh Flin Flon weather

was the major contributor to respiratory ailments. Respiratory problems were believed to be on a dramatic increase. According to one doctor some of this might be attributed to the fitness fad which resulted in increasing numbers of people who exercise in temperatures down to minus 35 degrees Celsius.

- A few interviewees mentioned an unusually high incidence of stillbirths and infant deaths. Some interviewees were convinced that birth defects were due to the work environment in which the mother worked.

ATTITUDES TRANSMITTED

The different attitudes of the interviewees with respect to the effect of environment on health became quite apparent during the conversations and were recorded. Some interviewees felt that the Flin Flon environment, or the HBM&S environment, had absolutely no effect on their health. At the other extreme some interviewees felt that the environment should take almost total blame for major illnesses in Flin Flon. Most interviewees felt that the environment had a great deal to do with illnesses in Flin Flon but there were other factors contributing to the prevalence of certain illnesses. These factors included smoking, drinking, drugs, stress of lifestyle in Flin Flon, diet, exercise, chemicals in food and weather.

The impression left by the majority of the interviewees was a very nonchalant attitute toward the whole issue of environment and health. However, it was hard to document this impression. Many interviewees thought that the hazards existed in the Flin Flon area even with the new stack. Many thought risks came with the job and they accepted danger as a fact of life since "there are gambles with every occupation" and "indeed walking across the street is a hazard". Some interviewees felt that environmental dangers in Flin Flon were no worse than in any other town or city in the country and some interviewees considered Flin Flon residents quite well off in terms of dangers to health from the environment. One interviewee stated that "the prairies blow dust; the cities smog and industrial pollution". Many interviewees also contradicted themselves. They discussed their concerns about the risks of the environment and then summed up their opinions by stating that Flin Flon was the perfect place to live.

INTERVIEWS WITH UNION LEADERS

TRADE UNIONS

The main concern of the International Association of Machinists and Aerospace Workers, Flin Flon Lodge, was lead poisoning, especially in the smelter and zinc plant. It was their opinion that employees had high lead levels in their blood. When high lead levels were found, the employees were temporarily moved to another area until that level decreased. Since blood tests were purely voluntary, many employees did

not go to be tested for fear of finding that they had a high level and would be moved to a less desirable job. Sometimes such a move to another job was permanent. According to the Union, testing for lead should be compulsory.

Another concern was the improper handling of asbestos. Loose asbestos still falls from the walls, and fibres are spread throughout the work area. Conditions were said to be worst in the baghouse. Knowledge and precautions have increased, but more work needs to be done to remove the risk of asbestos exposure.

Other concerns were arsenic in the furnace area, as well as generally poor ventilation throughout the plant, especially in the winter when everything is boarded up.

The International Brotherhood of Electrical Workers, Local 598, had varying concerns. One was the use of PCB oil in old transformers which were slowly being replaced. It was stated that in the past they were improperly handled and disposed of.

There was some concern about chemicals which were once used in the plant but are not longer present. In some cases new information has since come out about the health effects of these chemicals. No one was aware of these effects at the time they were used. A comparison was made to the notorious "agent orange" which was once considered to be safe but is now known as a cancer inducing agent.

The International Brotherhood of Electrical Workers, Local 1405, agreed with other Unions that the smelter and the zinc plant were the worst workplaces at HBM&S. This Union was also concerned about the negative effects of HBM&S on the Flin Flon environment especially on lakes and foliage.

Other Trade Unions which were contacted (International Brotherhood of Boilermakers, Iron Workers, Blacksmiths, Forgers and Helpers, Local 451, Brotherhood of Painters and Allied Trades, Local 1497, International Union of Operating Engineers, Local 828) generally agreed with this position. They worried most about the smelter and the zinc plant, particularly about the tankhouse's acidic air, and the fuming plant's asbestos, coal dust, toxic gasses and lead. All Unions were very concerned about sulfur dioxide emissions and heavy metals falling on the Flin Flon area. They felt that it affected the environment, as well as the health of the people. The diseases which they identified as most worrysome and prevalent were related to respiratory problems and cancer.

The Trade Unions felt that HBM&S should take more initiative in carrying out safety measures. It was stated that, rather than taking the initiative, the company would not say anything until the employees or Unions raised the concern.

STEELWORKERS

The United Steelworkers of America, Local 7106, generally took the same viewpoint as the Trade Unions. Although there were several health hazards present from the moment one stepped through the HBM&S gate, the places for concern were the various areas in the smelter and the zinc plant. Lead poisoning, arsenic, toxic fumes, sulfur dioxide, asbestos, and dust were identified as specific hazards. The Union felt that masks helped at the moment but were not the long term answer. HBM&S has been slowly improving, but the improvements have to continue much faster to insure the safety of the employee.

The view of this Union was that while a variety of environmental studies has been carried out in the general Flin Flon and HBM&S area, not much action has ever been undertaken as a result of these studies. Now, the Steelworkers are pushing not only for environmental studies, but also for medical studies on the people of Flin Flon; and especially on HBM&S employees. Instead of making assumptions about health based on environmental data, such studies would hopefully show exactly what the work environment does to the employees' health.

The steelworkers felt that the ultimate goal of such a medical study would be to provide a proof for the relationship between the environment and health which would encourage new industries, such as mines, to build all of the safety features into the plant right from the start. If this was to happen, the companies would not need to worry about the health hazards and employees' reaction to them.

The Steelworkers felt further investigations into safety and health hazards were necessary. There were a large number of unanswered questions because much medical and environmental information was being held back. The truth must come forward before anything can be done.

The Union found it hard to understand "why the Company is so reticent to make improvements to the plant. It would be in their best interest to remodel. Any improvements they make for safety and efficiency will pay for themselves within only a few years. HBM&S will benefit, the employees will benefit and Flin Flon residents will benefit (not to mention the wildlife and foliage)".

PUBLIC MEDIA

Occasionally, as noted in The Reminder, a Flin Flon citizen would have written grievances against the pollution caused by HBM&S .

Mrs. Stevens followed the environmental condition of Flin Flon for several years and wrote several articles. She had a special interest in the pollution of lakes. For years she was trying to obtain more public support in order to progress faster. Note two articles entitled "Pollution Aired at Flin Flon Hearing" (Winnipeg Free Press, Febuary

12, 1970) and Letter to the Editor in The Reminder on November 28, 1974. (Appendix pages 1 and 2).

Although John Milner was a resident of Cranberry Portage he was none the less concerned about the Flin Flon environment. He wrote articles on pollution caused by HBM&S. Noted are Letters to the Editor, "Stinks", 1980 (Appendix page 3) "Environment" May 15, 1981 (Appendix pages 4 - 5). He also wrote a follow up letter which according to him was never published due to the length of the article. It is included in this report; entitled "Rain of Death" (Appendix pages 6 - 8).

Several articles concerning acid rain in Flin Flon and Thompson were written in November 1979 (Appendix pages 9 - 13).

In the Miners' Voice several articles were published concerning hazardous environments in mines and mining communities.

Two articles dealt specifically with HBM&S. The first one entitled "Smelter Conditions are Indescribable" (September 1976, Appendix pages 16 - 17), described the hazardous environment of the smelter in Flin Flon. Several health risks for those working in the area, in addition to health risks for the community were discussed in the article.

The second article entitled "Compensation Boards Won't Touch Them" (March 1977, Appendix page 18) discussed the problem of emphysema, considered a non-industrial disease, by using the case of Russ Armitage as an example. This man worked in the crusher for 34 years and developed emphysema. For years he sat at home with oxygen tanks - getting tired while walking from one room to another. (The steelworkers fought approximately six years to prove that his emphysema had been caused by his dusty work environment. Mrs. Ruby Armitage eventually received a settlement after her husband's death.)

SUMMARY

A small number of interviewees felt that Flin Flon was the ideal living environment. There were more interviewees who felt that the environment was detrimental to health. Those residents who felt most strongly about the effects of the environment on health were trying to get involved in order to undertake action against polluting the environment. The vast majority of citizens were somewhat concerned, although not enough to become actively involved. As a result, there was little public action undertaken. People knew the hazards but they accepted them as facts of life. They feared that if they did not accept the hazards, the Company would close and jobs would disappear. They saw the cost of clean up as prohibitive.

The majority of concerned workers felt that the smelter and the zinc plant were the most hazardous areas inside the Company. They could not confirm that the stack emissions adversely affected their health but they knew it could not be good for them. In terms of health effects, the major perceived illnesses were respiratory, cancer, and heart problems.

APPENDIX

THURSDAY, FEBRUARY 12, 1970 The Free Press

Pollution Aired At Flin Flon Hearing

By TOM DOBSON

FLIN FLON, Man. (Special) — Two applications under the Clean Environment Act and views of several representatives of local organizations were presented to the seven-man commission responsible for issuing licences at a hearing here Tuesday.

The town of Flin Flon and the Hudson Bay Mining and Smelting Company were seeking interim licences to dump waste material in the water chain that passes through the community. The latter also sought permission to release smoke into the air from its base metal operation.

Town engineer John Munson presented the application from the town to dump sewage waste into Ross Lake from a plant that has been in operation since 1950. The application also mentioned 25 homes that are serviced by septic tanks with one dumping into Ross Lake and the second into Hapnot Lake, both within the town limits.

Although the sewage plant is treating 550,000 gallons daily and has a rated capacity of 450,000, Mr. Munson felt this would not mean it was overloaded. He pointed out there was no industrial waste entering the system.

Questioned regarding the amount of detergents and resulting phosphates being dumped into the lake Mr. Munson said this was not known as there was no equipment here to make such tests. He wondered about the accuracy of any test if the discharge was sent all the way to Winnipeg.

Local housewife Mrs. Bert Sevens, Steelworkers' union representative Bill Hanna and chamber of commerce president Fred Howard all spoke on the town's application.

Mrs. Stevens claimed Ross Lake has now been killed by Schist and Athapapuskow lakes pollution, and the runoff into was threatening to ruin both these bodies of water. She was of the opinion all pollution must be stopped immediately.

Mr. Hanna wondered if the town should not have tests of the waste it is dumping. He wondered if the commission would bring pressure on the town if it discoverd the sewage plant was not working at 100 per cent perfection.

Mr. Howard said the chamber he represented was confused and although it was realized both the town and the mining company must be granted licences in order that the communtiy could continue to exist, he wondered if something was going to be done about pollution.

Mr. Howard mentioned a meeting held in Montreal in 1966 on pollution and since that time commissions have been spending money running around the country, and volumes of books have been produced but actually what has been done to stop pollution?

Regarding the local hearing and the clean environment commission he wondered "if we are in the wrong room and if there was somewhere else those voicing objections should go."

"What is the Manitoba government going to do tomorrow and not five years from now?" he asked.

Commission chairman Dr. Peter Warner said there is worldwide concern over pollution and as a result the Manitoba government had passed the Clean Environment Act. He felt the commission was made up of responsible men and they would certainly do as much as they could. He suggested governments are trying to find the middle of the road, and agreed it would certainly cost a lot of money to solve pollution.

In presenting the mining company's application general manager Dave Robertson traced the history of the mining operation and the continuous research that has been conducted to extract the valuable ingredients from the ore. He suggested the improved recovery resulted in a gradual improvement as far as wastes being dumped into the water and air are concerned.

He revealed the waste from the mine contained sulphates and chlorides of magnesium and calcium and traces of the various minerals contained in the ore being treated. The smoke coming from the plant contained sulphur dioxide and he suggested it would be very difficult to recover this ingredient.

Regarding the possible trapping of the sulphur for producing sulphuric acid he pointed out the market was not available for this commodity from the plant at Flin Flon. He stressed the difficulty of removing the sulphur in the local operation because of the lack of the proper concentrating of the gas.

Mr. Robertson said it was impossible to increase the height of the two major stacks at the smelter and zinc plants with the present foundations.

Mr. Robertson in answering a question from a commission member said the company had not received any formal complaints from representatives of the people in Flin Flon or from any organizations. He did mention reading complaining letters to the editor in the local paper from time to time.

In his explanation of the plant operation Mr. Robertson said two dams were located in the tailings settling area to collect solids with 6,000 gallons of the runoff going over the second dam and into a creek leading into Ross Lake.

Mrs. Stevens claimed the dams developed breaks on a number of occasions to send over sludge and heated water that created a fog condition in the area. It was her opinion the smelter smoke created much destruction within a 15-mile radius of the plant.

Mr. Hanna for the Steelworkers objected to the mining company's request for an interim licence unless some stipulations are applied to clear up pollution of the water and air. He felt it was up to the commission to deal with the applications in a manner that would bring this about.

He was concerned that the town council was not running tests on the sewage plant and doing more to increase the efficiency of the operation.

Mr. Hanna claimed large mining companies in other parts of Canada were spending huge sums of money to clean up their operations and suggested that 20 per cent of the Hudson Bay Mining and Smeling profit for one year could produce four or five million dollars for that purpose.

Mr. Hanna said the people he represented are interested in air fit to breathe, water fit to drink and soil that is not contaminated.

Other speakers were heard and at the conclusion of the well attended hearing a commission member said it was perhaps impossible to remove all contamination if industry is to continue and man to progress.

It was his opinion the Clean Environment Act was established to set a standard in order that people would have a healthy place in which to live. He suggested it was impossible to make changes overnight but these improvements could be made on a gradual basis.

The Reminder
HURSDAY, NOVEMBER 28th, 1974

LETTERS TO THE EDITOR

Dear Sir:

It was interesting to read Bob Lowery's article in the November 25th issue of the Daily Reminder wherein, at some length, he praises the Hudson Bay Mining & Smelting Company for its environmental concern with regard to its operations in this area. All things considered, we would be greatly remiss if we failed to acknowledge, as well, the efforts of the non-corporate citizens of Flin Flon/Snow Lake who were largely instrumental in bringing these environmental issues to a head and thus toward a settlement.

It is not difficult for those who participated to recall the many meetings which were held here, most particularly before the Manitoba Clean Environment Commission, where citizens made numerous strong representations against the polluted status quo. And behind the scenes, many of these dedicated citizens continued the silent battle, writing numerous letters to government and corporate bureaucrats, including the local HBM&S General Manager, indicating positively and in no uncertain terms how the Company, with its vast industrial and technological resources, could be one of the mighty leaders in anti-pollution measures, and of how such efforts would beat all the public relations gimmicks the Company could employ. Furthermore, it was pointed out that a finger in the pollution-control pie, through acquisition of purification firms and marketable equipment, could prove to be (and now is) very lucrative indeed.

Mr. Lowery obviously ignores, or is unaware, that the Company - as publicly admitted by its General Manager (Reminder - Nov. 24/69), was "not prepared to voluntarily take the necessary measures to make Flin Flon pollution free". While we are happy to give credit where due, only to the extent that the Company responded to the agitation and protest of our citizens and their elected representatives does it deserve credit. Today, the Company meets environmental standards -- particularly at new mines such as Centennial - under the watchful eye of environmentalists and The Commission. Hopefully, in future, the Company will act as beneficent leader rather than reluctant follower.

In the meantime, let us pay tribute to the local citizenry; the man in the street, and on the job, who was thoroughly fed up with local air and water pollution and darned well said so; to the women of the community who mourned lost gardens and shrubs, tended wheezing family members, and turned out to the meetings to raise hell; and to the letter writers.... Salute! Our social battles are far from won, but those unafraid to become involved have learned well that progress does indeed walk in Indian file behind the guy willing to stick his neck out.

M. G. S.

1980

p3

"Stinks"

Editor:

It Stinks!

On a beautiful day in the mid-sixties, I visited a friend in Flin Flon to discover that much of his garden and shrubs had perished from the effects of smelter smoke. My host, at that time an employee of HBM&S, fatalistically replied that, "it happens every once in a while". Thank goodness the 800 foot plus smokestack is now belching its killing fumes beyond the citizens of Flin Flon.

But behold! The other morning I smelled the foul vapor in the air of Cranberry Portage. It is almost, but not quite, the same odor I occasionally smell from the Manfor stack when the wind is from the southish.

Thanks to a few pollution sensitive citizens and some government pressure, Flin Flon air is now much cleaner since the stack now dumps "on the rest of the world".

People in The Pas that I have spoken to about their problem, are always quick to point to the economic effects of the Manfor operation. Granted, but why are we so resignedly accepting the slow, silent death dealt by the nauseous fumes upon ourselves and upon our natural environment?

If our economy is healthy is that not all the more reason to maintain a healthy environment?

The stink is obvious, but what about the contaminating solid particles and chemicals sneaking unnoticed into our waters?

Not too long ago it was announced that five lakes in the Flin Flon area were seriously affected by "acid rain". How the smoke stack companies and the government are monitoring the acid rain effect which is becoming more serious daily, downwind as far as the Ontario border.

While this continues, I think it is time that we northerners placed pressure on the appropriate authorities to halt smokestack pollution. Southerners do not as readily tolerate situations like ours and we have lived with our sky sewers only because we have not kicked up a "stink". Our society does have the technology to control pollution in stacks and holding lagoons. I feel it's about time the public put on some pressure.

Let's get involved! Together we can do something about this matter.

I do not work for government or company and I am willing to help lead the campaign if there is some citizen support. Let's hear from you.

The life we save could be your son's o daughter's and may tu out to be another Ter Fox.

John Milner
Cranberry Porta

the reminder

FLIN FLON, MANITOBA FRIDAY, MAY 15th, 1981

LETTERS TO THE EDITOR

Environment

Dear Editor,

Last fall I submitted a letter to the editor which I hoped would draw attention to our environmental pollution. The purpose of the letter was to organize support from environmentalists and concerned citizens. As a second step, I would like to point out the degree of atmospheric contamination to which the Flin Flon area is being subjected to.

The purpose in submitting this second letter is not to be melodramatic even though the magnitude of the problem easily lends itself to sensationalism, but rather to be informative and to bring the problem home to the stomachs and hearts of the people of the area around Flin Flon.

I will refer to a pollution study done on 23 lakes in our area and will single out data for one lake, Cliff Lake, the source of Flin Flon's water supply. This study Oceans, Canada, between August, 1976 and July 1977. The reader should keep in mind that the results refer only to the fallout on Cliff Lake which has an area slightly less than 2½ square kilometers. The study covers an 85 day snow

If this rate of deposition has held true, on this lake, since the mine began in 1930, the total arsenic fallout alone, would be over 2,400 pounds.

The data cited for Phantom Lake is more than three times greater than that for Cliff Lake. The Creighton water supply (Douglas Lake) has about one-fifth the fallout of Cliff Lake. The data generally shows that the farther you are from the smelter, the less the fallout.

For example, Simonhouse Lake, over 30 kilometres away has only one-sixth the deposits per square kilometre that Cliff Lake receives. The study further states, "...the Flin Flon smelter is a significant source of airborne Zn (zinc), Cd (cadium), Pb (lead), As (arsenic), Cu (copper) and possibly SO_4 to as much as 250,000 km^2 of the environment in the vicinity of the smelter."

In 1977, HBM&S estimated that the 825 foot stack emits the following pollutants (per 24 hour period): cadmium 390 lbs., copper.820 lbs., lead 2970 lbs., zinc 15,000 lbs., total particulate matter of 58,000 lbs. In July 1977, Environment Canada estimated that the stack also emits 1,300,000 lbs. of sul-

Deposits of Metals on Cliff Lake (85 snow days)

Metal	Lbs. - 85 days	Est. lbs. per yr.
Iron	154	662
Manganese	5.7	24.6
Lead	85.8	368.9
Arsenic	11	47.3
Cadmium	7.3	31.2
Copper	226.6	974.4
Zinc	3,658.6	15,732
Total	4,149.0	17,840.4

To put this problem in perspective it should be noted that in 1974, the Department of Health, Education and Welfare of the United States, through a complex and conservative formula, estimated that each pound of sulphur dioxide emitted in the United States, costs the general society 12.5 cents in environmental damage. This formula included damage to human health, vegetation and property but does not include SO_2 damage to animals (fish) and soil.

In the report, "The Sudbury Pollution Problem," this formula was applied and it was estimated that approximately $465,850,000 of environmental damage was caused by emissions each year. If the above estimates hold true for the Flin Flon area, the emission of SO_2 alone is causing $59,000,000 of environmental damage per year (in 1974 dollars).

A joint federal-provincial study (Hogan and Wotton) concluded that,

"Smelting activities in the Flin Flon area have lead to a general decline in the forest community in the immediate vicinity of the smelter."

"Severe degradation is obvious in relic jack pine and spruce studs located a few kilometers to the south of the smelter complex. Those sites are depleted of species which are sensitive to atmospheric pollutants."

"A complete absence of lichens and other biophytes was observed at these sites indicative of the intensity of fumigations which have occurred in the past. Severe erosion has taken place at these sites and the thin mantle of soil which was present on outcrops has been lost."

I wish to pose this question to the reading public. "Can we continuously subject humans and the environment to trace amounts

LETTER

adverse effects?" ~~The technology to~~ clean up our dirty air exists. It makes economic sense to employ more people; people to build and install the pollution control devices and people to run maintain and monitor them. This pollution can be stopped in the immediate future and in doing so we will have employment created, precious metals reclaimed as well as providing a healthier environment for mine workers, ourselves and our grandchildren.

During 1978 and 197 the emissions from the plant exceeded Saskatchewan's maximum environmental standards at Creighton and Phantom Lake 201 times and exceeded Manitoba's more lenient standards 44 times. According to their most recent agreement with the Clean Environment Commission, dated April 10th, 1981, (Order No. 899VO) the company has a license to continue its present pollution program until January 1st, 1974.

As I stated at the outset, the object of this letter is to be informative and not to create public panic. It is true that the most recent chemical analysis of water from six locations in Flin Flon (February 2nd, 1981) shows that the elements listed above are not present in amounts which exceed the maximum allowable standards set forth by the Province of Manitoba. For example, the maximum allowable arsenic is .05 milligrams per liter while the Flin Flon supply has only one tenth this amount (.005). However this is still five times more than the objective the province sets for good drinking water standards. Similarly for lead, the maximum allowable is .05. milligrams per liter and the objective is .001 while the analysis shows Flin Flon taps to have between five and 15 times the objective, depending on the location the sample was taken from.

Under the terms of the company's agreement it is not likely that immediate action to stop or reduce stack pollution will occur, so meanwhile if anyone has a pet lake listed among the 23 studied, I would be more than willing to read out the pollution deposition for your lake, as cited in the 85 day snow accumulation study.

My phone number is 472-3353, Cranberry Portage.

John Milner

MARCH 1977 The Miner's Voice

'Worse than silicotics'

Compensation boards won't touch them

FLIN FLON, Man.

Russ Armitage is sitting at home and not doing anything, and that makes men like Steve Hamon mad.

Hamon is president of Local 7106 of the Steelworkers at the big mine and smelter operated by Hudson Bay Mining and Smelting.

Armitage worked for 34 years in the mill, one of the dustiest places in the operation. Today he has emphysema, the lung disorder. The disease forced doctors to order him not to work since 1975.

"He gets tired right away if he even goes for a walk," says Hamon. "He says, 'I'm not that old but here I sit and can't do anything.' "

Armitage is 63.

He is one of many workers from mines, smelters, and other industries whose disease isn't recognized as an industrial illness by provincial compensation boards.

In Toronto, Steelworkers' safety department representative Lorne Heard says he can recollect only one case of a

LORNE HEARD
Boards say no.

compensation board giving any money to a victim of emphysema. The compensation boards blame smoking, not working conditions.

Heard and others, however, who have to fight for pensions for men like Russ Armitage are convinced that working conditions play a role in the development of all lung disorders.

"Lots of people who don't smoke can also get emphysema," says Heard.

Silicosis is recognized by provincial boards as an industrial disease. It also develops from exposure to dusty conditions. Why not compensate for emphysema?

"The guy with emphysema is really worse off than the guy with silicosis," says Heard. "Some silicotics can still work if their disease is spotted by doctors early enough.

"In most cases the silicotic can be removed from dusty conditions, and they won't get sicker. But the guy with emphysema has a disease that can make him more susceptible to lung cancer and tuberculosis."

Welders, structural steel workers and ship-building workers also are exposed to dust and develop emphysema, says Heard. The problem is one that compensation boards are going to have to grapple with soon.

Hamon says Flin Flon has other cases like the Armitage one. In the last five years there have been about 20 special early retirements. The men forced out of their jobs don't get full pensions. Hamon suspects some of these men have emphysema or other breathing ailments that Manitoba's compensation board won't recognize as work-related.

What's most aggravating to Hamon and other local union people fighting for compensation for emphysema victims is doctors can't agree on whether it's related to work. One doctor in Saskatchewan has told Hamon that Russ Armitage would be eligible for compensation if he lived and worked in Saskatchewan because of the damage that shows up on his X-rays.

The Hudson Bay mine is actually on the Saskatchewan-Manitoba border. One mile on the other side of Flin Flon, Russ Armitage could be getting some badly needed extra money to compensate him for the wages he's losing.

RUSS ARMITAGE
Unable to work.

CHAPTER II

GENERAL ENVIRONMENT OF FLIN FLON

F-417/82 p6

RAIN OF DEATH

In the scenic wilderness forests of the Canadian Shield, there are 200 peaceful, sparkling lakes. These are the kind of lakes chosen by Provincial Governments and by tourist ads which are used to entice vacationers to the North. The lakes appear as an ideal retreat for outdoor enthusiasts, tourists, and fishermen. The waters are sparkling clear and tranquil. The waters are also 'acid dead.'

The waters are clear because "acid rain" has destroyed all life in them. They are tranquil because they are devoid of all swirlling aquatic life.

These lakes are in Ontario. Ontario also has thirteen hundred other lakes which are listed as, "being on the verge of acid death." Given the present emission levels of acid rain, the Ontario Environment Ministry claims that within 17 years 50,000 more of Ontario's lakes will no longer be able to support fish life.

This has happened because of acid rain. Can it happen here? the answer is, it "is" happening here.

"Acid rain" is rain that is more acidic than would be found in a natural, manless environment. To understand the degree of acidity, scientists use a measuring scale called the pH (potential hydrogen) scale. The scale runs from zero (maximum acidity) to 14 (no acidity). A pH of 7 represents a neutral solution. The scale is logarithmic which means there is a tenfold difference between one number and the next one to it. A drop in pH from 7 to 6 means that the acidity is ten times greater; from 7 to 5 is one hundred times greater, and so on.

As examples; milk of magnesia has a pH of 10.4 and baking soda a pH of 8.4. These substances are often used to counteract acid indigestion. The pH of distilled water is 7.0, of vinegar 2.9, of lemon juice 1.9, and of battery acid below 1 - 1,000,000 times more acidic than distilled water.

The pH of normal rain, 5.6, is somewhat acidic because of the carbon dioxide in the earth's atmosphere. By the time this slightly acidic natural rain washes

across the land, other chemicals tend to neutrlize it and it ends up much closer to neutrality, pH 7.

In ten years, many of Ontario's lakes dropped in acidity from pH 6.8 to pH 4.4.

What does this do to fish? Walleye (pickerel) lose the ability to reproduce at pH 6.0 to pH 5.5. Northern pike, being a hardier species, lose their reproductive ability at pH 5.5 to pH 4.7. But no lake fish can survive a pH below 4.5.

Now none of our northern lakes register pH values of 4, but, two other fish fatal forces are at work at much higher pH values.

As accumulated acid-loaded snow melts in the spring, it can produce fatal "acid shock" in the spawning streams. Even more critical, the high acid run-off leaches highly toxic aluminum out of base rock. A two to three day exposure to these toxic spring episodes can be fatal to spawning fish and can prevent embrionic development in the eggs.

The second set of fatal conditions involves the intake and retention of poisonous methyl mercury. (This chemical was responsible for the tragic deaths of many people in Minamata, Japan.) As acid concentrations increase the amount of methyl mercury leached from natural rock also increases. As material containing methyl mercury is taken in by fish it accumulates until a toxic level of mercury poisoning occurs. The most recent, critical mercury poisoning episode occurred in Northwestern Ontario in the English-Wabigoon Rivers system.

Does acid precipitation exist in our area? Athapapuskow, Amisk, Birch, Tulabi, and Tyrrell Lakes have all recorded acid snows with pH values between 4 and 5. Those lakes which have had values recorded between pH 5.0 to 5.6 include: Cliff, Lake 6, Precipice, Kisseynew, Thompson, Simonhouse, Patmore, Meridian, Howell and Nesootao.

Experts explain that acid rain is mainly the result of emissions of sulphur and nitrogen oxides from smelters, coal-burning plants and combustion engines. In Canada, the non-iron smelters produce 48.8% of the sulphur dioxide emissions. The

p8

Inco smelter at Copper Cliff (Sudbury area) is the single largest point source of acid rain on the continent. Its 'superstack' (1200 feet) emits 5,200,000 pounds of sulphur dioxide each day. Second is Noranda - 3,242,000 pounds, followed by Inco Thompson - 2,164,000 pounds and HBM&S with 1,277,000 pounds per day. (These figures are available from; Canada: Air Pollution Control Directorate, 1981.)

Acid rain's effect on fish is serious but it costs Canadians far more in terms of soil devastation and destruction of crops, forests, structures, metal equipment, and human health. The Royal Commission Report on Acid Rain, 1981, estimates that if Inco's, Sudbury emissions were reduced by 50%, human health costs alone would be reduced by $500 Million per year. The Report further suggests that a 50% reduction in Canada's emissions could generate up to $15.5 Billion in annual benefits to Canadians.

The Environment Ministers across Canada describe the acid rain problem,"as the most important environmental problem of our time and it dictates that corrective action must be implemented now." Our present course may become irreversible and taken to the limit, could lead to annihilation of aquatic and land-life on this planet.

The technology is available to halt "the rain of death!" It has not been put in place because it has been cheaper for industry to pollute than to contain its pollutants. Further, industry has no social conscience and feels no moral obligation to society. Generally the attitude of industry has been one of, 'let the citizens pay to clean up the damage that our sewers-in-the-sky create.'

One solution is to have stringent government controls and heavy fines for pollutors. Too often government and industry are bedfellows and the political will to set rigid controls does not exist. To overcome the political clout of industry, electors will have to lay 'heavy duty pressure' on their legislators. Help insure a healthier future for our children. Register your concern with your MLA and your MP. Get your submissions ready for the public hearings that the Clean Environment Commission will hold before HBM&S's "license to pollute" expires, Jan. 1, 84.

John Milway
Pembina Portage

the reminder

N FLON, MANITOBA WEDNESDAY, NOVEMBER 7th, 1979

Acid rain hazards increase according to Winnipeg scientist

A Winnipeg scientist said potential hazards from acid rain are increasing for the Northern Manitoba mining communities of Flin Flon and Thompson.

Dr. David Schindler said he would be "afraid" to live in those areas, knowing what he does about the effects of pollution from mining and smelting operations.

Schindler, a researcher for the federal Freshwater Fish Institute in Winnipeg, said in an interview yesterday high levels of sulphuric and nitric acids have been found in three lakes in the Flin Flon area. He said the problem may be as serious at Thompson.

The Hudson Bay Mining and Smelting Co. is located in Flin Flon in the northwest part of the province while Inco Metals Co. has a large operation at Thompson, about 630 kilometres north of Winnipeg.

Schindler said government restraint programs are interfering with research which could lead to smelters being forced to cut back emissions which cause acid rain.

The rain is produced when sulphur or nitrous oxides are dumped into the atmosphere and mix with water vapor. Ultraviolet light acts as a catalyst for the slow chemical reaction which creates the acids. - CP

the reminder

FLIN FLON, MAN. MONDAY, NOVEMBER 19th, 1979

LETTERS TO THE EDITOR

Acid Rain "MISQUOTED"

Note: The following letter was sent to the Winnipeg Tribune concerning what Dr. D.W. Schindler calls "an erroneous story about acid rain in Manitoba's north."

Editor:

In the November 7 edition of the Tribune you ran an item, "Acid rain growing in province's north: Expert," based on an interview I had with one of your reporters.

It was a valiant effort. Unfortunately, the article distorts and reverses nearly everything I said in a way that seriously misleads and misinforms your readers.

To compound the misconception generated by the story you ran an editorial, "Deadly rain falls in North," on November 9. I ad-

(Cont'd Page 12

ACID RAIN

mire the sentiment - bravely expressed - but the essential facts were, and still are, incorrect.

In reference to the editorial, perhaps the "...Winnipeg based authority (who) says there is a growing (acid rain) problem at Flin Flon and, probably, at Thompson..." should have been named or if the editorial sprang from the erroneous story, which is what I suspect, I should have been consulted.

I would like to set the record straight on problems in northern Manitoba as far as the department of fisheries and oceans is concerned.

Paragraph three of your original story quotes me as saying that I would be "afraid" if I were living in the Flin Flon area. The actual word I used was "concerned". What I expressed concern about was heavy metal deposition, not acid precipitation. The parapgraph states that I said high levels of sulfuric and nitric acid occur in three lakes in the area. What I actually said was that our department's studies had revealed that high concentrations of cadmium and zinc occur in the lakes. To my knowledge there is no acidification problem in Flin Flon lakes.

The next paragraph quotes me as saying that acid rain has been detected in the area. I actually said that the only data set collected by our department, for snow chemistry, indicated that acid precipitation was not a problem in the Flin Flon area.

In a subsequent paragraph I am quoted as blaming government austerity programs for the failure to force large companies to cut back on emissions. I don't see any relationship between government austerity and emission control.

What I actually said was that government austerity had forced scientists in our agency to postpone plans to investigate acid and heavy metal deposition programs in northern Manitoba. I also said that control of emissions of oxides of sulfur and nitrogen was the only way of halting acid precipitation.

In summary, the public should know the following facts on this important issue: (1) there has been no acid precipitation problem detected in northern Manitoba to date; (2) cadmium and zinc concentrations in a few lakes near Flin Flon exceed most drinking water standards and similar concentrations have been shown to the toxic animals in laboratory studies, but because of inadequate data, we do not known how widespread the problem is at present; (3) there is a need for further monitoring of precipitation and lakes in northern Manitoba in order to clarify the extent the magnitude of current and future problems.

Yours truly,
Dr. D.W. Schindler
Program Leader
Experimental
Limnology
Department of Fisheries and Oceans

the reminder

FLIN FLON, MANITOBA WEDNESDAY, NOVEMBER 14th, 1979

Company refutes acid rain charges

Hudson Bay Mining and Smelting Company today refuted charges in recent newspaper reports that acid rain was present in lakes and streams in the Flin Flon area as the result of the company's metallurgical operations.

In a statement issued by Keith Callander, general manager of Hudson Bay Mining's operations at Flin Flon and Snow Lake, said company officials have for years been concerned about the ultimate destination and effect of the sulfur oxides discharged from the Flin Flon metallurgical complex.

He said since 1972, the company has undertaken three extensive surveys of lakes in northern Manitoba and Saskatchewan and has not found any lakes demonstrating those effects attributed to the phenomenon of acid rain.

(Cont'd. Page 9)

ACID RAIN

The most recent survey was completed this fall, according to the general manager. In the survey, he said, all major lakes, river systems and watersheds were sampled within some 105,000 square kilometers of Precambrian Shield country surrounding Flin Flon.

Callander said only three of the locations sampled demonstrated acid levels below that considered neutral and all three were from water bodies receiving acid drainage from major muskeg areas. He said none demonstrated any other scientific parameter which would indicate the presence of acid rain. "Generally, any water which is neutral or only slightly acidic is recognized as acceptable for fish."

Callander said the company wishes to point out that data on rainfall collected by Environment Canada, indicates that rain in areas of Manitoba and northeastern Ontario does not demonstrate the acid values found in more easterly parts of Canada, and in fact are less acidic than those found in normal rain. Reference was made to a Winnipeg Free Press article printed July 17. At that time, Dr. D. Schindler of Federal Freshwater Fisheries, an expert on acid rain, was reported as stating that "Manitoba's lakes are not in danger of dying from acid rain." The article also quotes Dr. Schindler as saying "Manitoba is probably the best place to live in all of North America".

minder

THURSDAY, NOVEMBER 8th, 1979

Acidity count below normal claims environmental official

THOMPSON - Constant monitoring of industrial smokestacks in northern Manitoba has not found any evidence of acid rain, a Manitoba mines and environmental management department official said this week.

Dr. George Bowen, assistant deputy minister for environmental management said the acidity count in the northern Manitoba lakes and rivers is well below the danger levels recorded in southern Ontario and Quebec.

He added that in the areas affected by gases from industrial plants in the United States and Canada as well as from eastern mining operations, the count is four ph (a measurement of acidity in water).

The ph measurement runs on a scale from one to 14. Mid-point, seven, is neutral. Below this point is an increasing level of acidity with one the highest. Above seven ph, water has an increasingly alkaline content.

Northern Manitoba rivers and lakes, Bowen said, are mainly registering seven ph (neutral) with some slightly above, giving a light alkaline content. He said calcium in rocks gives the water a natural alkaline content. As well, water coming into Manitoba from the west also has higher alkaline.

According to the ph scale, which increases on a logarithmic scale, a reading of four is

(Cont'd. Page 16)

ACID RAIN

actually 10 times greater than a reading of 5 ph.

As well as gas, both fauna and flora in the forests are constantly studied by the department, Bowen said. There is no evidence of change, but, he said there had been damage to the forest in the immediate area of Thompson's Inco stack. - reprinted from Winnipeg Free Press.

the reminder

FLIN FLON, MANITOBA WEDNESDAY, DECEMBER 12th, 1979

Waste ruling upheld

WINNIPEG (CP) - The Manitoba Cabinet has upheld orders placing tighter limits on waste disposal by Hudson Bay Mining and Smelting Co. from two mines in the Flin Flon area.

The company appealed to Cabinet last June to overturn the orders issued by the provincial clean environment commission.

The orders prohibit the company from dumping liquid mine wastes or sewage directly into Lake Athapapuskow and Schist Lake. Instead, the wastes must be piped to swampy areas near the mines, except during emergencies.

The Cabinet also refused to loosen limits on allowable concentrations of heavy metals in liquid waste or extend the company's deadline for meeting the limits.

MONDAY, FEBRUARY 11, 1985

Gov'ts agree to reduce emissions

The cost may range from $50 to $50 million to control sulphur dioxide emissions from two major Manitoba smelters, said Environment Minister Gerard Lecuyer in a telephone conversation Friday.

The estimate comes as a result of feasibility studies conducted at both Hudson Bay Mining and Smelting Co. Ltd., locally, and Inco Ltd. in Thompson which operates a nickel smelter. Studies were conducted by the companies when they were identified as two of Canada's 10 major producers of sulphur dioxide, (the component responsible for acid rain), and the province's major emitters of the sulphur dioxide.

Last Tuesday, the province signed a federal/provincial agreement to reduce sulphur dioxide emissions by 188 metric tons by 1994, which would allow for a projected ceiling level of 550,000 metric tons annually. This compares with the current ceiling level of 738,000 metric tons annually, a level which the companies have not yet reached according to the minister, due to a general slowdown in the mining industry.

Howevery, Lecuyer said production was expected to increase next year and escalate to maximum production within the next two years. But he added that he expected Manitoba to reach its 1994 targetted goal well before the deadline date.

The seven provinces east of the Manitoba - Saskatchewan border have all participated in the agreement.

Lecuyer said financial help will be forthcoming to both companies to implement the new technology needed to restrict emissions, however, said details would have to be worked out with the respective companies.

The minister also said he plans to meet with the people of the community and company workers in connection with the issue..

"We want to protect the environment for now and the future, as well as wildlife and future resources for the health and well being of the people," said the minister. But he added that the government is not unconscious of the economic ramifications of the agreement and will work with the companies to reduce the negative impact.

the reminder Flin Flon

THURSDAY, MAY 30, 1985

Gov't to study smelter emissions

Environment Minister Gerard Lecuyer announced yesterday in Flin Flon that a preliminary study into the possible health effects of emissions from the smelting industry will be carried out in Flin Flon this summer.

Dr. Jure Manfreda of the Faculty of Medicine, University of Manitoba, will co-ordinate the environmental health study, together with the department. Dr. Manfreda is a well-respected professional who has been involved with a number of studies of this nature, said the minister. The doctor is also familiar with information on exposure to air pollutants in the Flin Flon area, said Lecuyer.

The study is being undertaken to determine whether a full epidemiological study of the Flin Flon area is warranted, added the minister. "Data for the area indicates that mortality rates for certain causes of death are higher than the average rate for similar size communities in Manitoba," the minister said.

"Concern has been expressed by a number of groups about the health of workers employed with the company as well as about the health of the general population in the vicinity of the plant."

Lecuyer said that bits and pieces of information have been collected through various government departments, but a mine study such as the one proposed by the government has never been undertaken. The study will incorporate the effects on the workers as well as the general population of the city.

He characterized Flin Flon as a "close-knit" area, ideal for such a study. He said such a study would not only help combat the negative effects which may exist locally, but would prove useful to other Manitoba communities which reflect similar situations.

It is estimated that about 40,000 workers have been employed by Hudson Bay Mining and Smelting Co. Ltd., since it began its mining operations, but many of the workers have been employed only short periods of time. It may prove difficult to trace these workers, he said.

The study will review all environmental data already collected on the area; review data on some air pollutants such as sulphur dioxide and heavy metals, and incorporate a search for death certificates for residents who have lived in the area.

Primary and secondary causes of death will be explored and data will be collected from other sources, such as unions the public and the company.

Data will be reviewed on worker exposure and information tabulated on the relationship between job classification and risk factors.

Work on the preliminary study will be undertaken by four summer students who will work out of Flin Flon and Winnipeg. The study will be co-ordinated out of the Winnipeg government office. One of the students is to be hired from Flin Flon.

Deputy Mayor Peter Mendro welcomed the study, saying it is long overdue for Flin Flon. And Bunny Barlin, assistant general manager of metallurgy and services, pledged the full co-operation of the company.

Further information on the study may be obtained from Ivan Sabesky, Industrial Hygiene, Manitoba Environment and Workplace Safety and Health

(Con't Page 18)

the reminder

Flin Flon

FRIDAY, JULY 19, 1985

Local study continues

A preliminary study, concerning the local environment and general health of the community, is presently underway with the result to determine if a more extensive study is necessary.

In order to complete the study locally anyone interested in contributing to the collection of information should contact Shari Pierangeli at 687-7195.

SMELTER CONDITIONS ARE "INDESCRIBABLE"
Steelworkers to lauch community health survey in Flin Flon.

FLIN FLON, Man

The 1,050 Steelworkers at Hudson Bay Mining and Smelting will launch a community health survey to find people who have occupational diseases but who may not know it.

The campaign is also an attempt to have the company, one of the world's largest mining concerns, improve safety in its mines and surface plants.

Three workers died last year at Hudson Bay Mining, and another died only this past June 29 in an underground mishap.

Provincial government inspectors have tested the air workers have to breathe on the job and found it unsafe. The company claims it can't afford to clean up and denies that conditions are unsafe in any case. Hudson Bay Mining profits in the past two years totalled over $53 million.

Lack of training is a major problem and is believed by Steelworkers' Local 7106 safety committee members to have caused death. Says one smelter worker, "the only training you get from the company after you're hired is 'Watch yourself.'" He says the smell of gas is indescribable, and conditions are obviously "very unhealthy."

Steelworkers' safety specialist Paul Falkowski of Sudbury toured the plant recently and made several suggestions to management that would reduce the risk of lung cancer and other diseases linked to exposure to pollutants in the air at smelters.

Local 7106 president Steve Hamon and financial secretary Charles Zimmerman toured the Trail, B.C., zinc tank rooms at Cominco, Ltd. in June with Local 480 Steelworkers and found those conditions much better than in Flin Flon.

But Local 480 is pressing for improvements, and Cominco is being fined more than $30,000 a month by the Workers' Compensation Board for failure to improve unhealthy conditions quickly enough.

"We'd like nothing better than to say the place is clean," says Hamon, the Local 7106 president, "but we know it isn't."

One move Hudson Bay Mining made in response to continuing demands by the Steelworkers for action on health was to bring in a new safety supervisor, Ian Montgomery. Montgomery notes that some ventilation "improvements" the company made with great fanfare are worthless.

Montgomery admits there's not enough training, but blames the high rate of turnover among the workers. Montgomery previously worked in South Africa and claims miners there get better preventive treatment for health problems than in Manitoba.

Jim Webber, a former chairman of the Steelworkers' safety committee, is directing the community health survey. Forms were printed by the union, and the Steelworkers hope to distribute one to every home.

The union is worried that even people who don't work in the smelter or underground could be in danger. The HBM and S complex is right inside the town, and most employees live in the shadow of the company's huge stack, which emits sulphur dioxide, dust, arsenic and other contamination.

Webber says tests on the atmosphere in the smelter prove the health of workers is in danger. In recent gov-

LOCAL 7106 MEMBERS MET RECENTLY TO DRAW UP BARGAINING DEMANDS; SAFETY IS EXPECTED TO BE A PRIORITY

LEE DAMBERGER

WESLEY SMITH

ERIC MARTIN

LAWRENCE KENNEDY

ernment tests for sulphuric acid mist in the zinc tank house, 31 of 57 readings were above generally recognized guidelines.

For sulphuric acid, the threshold limit value, for instance, is 1 milligram per cubic metre of air. But the Hudson Bay Mining tank house showed readings up to six times that level.

Emphysema and other respiratory illnesses, tooth erosion and other health problems are the results of exposure to sulphuric acid mist. Hamon has had two teeth capped because acid rotted off the enamel.

"If it's doing that to your teeth," says Hamon, "think what it's doing to your lungs."

When the union suggested that workers be provided with protective hoods to wear until the company improves ventilation, the company rejected the idea. The hoods cost $700 apiece.

The former safety superintendent wrote that "they are not practical for the job, the men will not wear them and we wouldn't expect them to."

Webber, a 29-year-old timberman underground, worked five years in the smelter and has devoted most of his union work to safety. He is former president.

He's been trying for years to get designated rescue stations underground with water, first aid equipment and food in case of explosions or cave-ins. Miners could be trapped for days until rescuers could dig them out. HBM and S has refused.

Webber also has demanded regular hearing tests for all workers, but the company has refused. He is now pushing the Manitoba and Saskatchewan governments for tests. A number of Flin Flon workers have been awarded compensation for deafness.

(The Flin Flon operation is unique because it straddles two provinces. For industrial relations federal law applies, but the federal government has no interest in occupational health, so it gives the responsibility to the provinces. Saskatchewan's inspectors tour the operation on the Saskatchewan side and Manitoba controls the other side.)

JIM WEBBER
More training a must.

"Mining inspection in Manitoba has been lax," says Webber. In Saskatchewan workers can refuse to work in unsafe conditions, but Manitoba doesn't provide strong protection to workers who refuse unsafe jobs.

Last year a Saskatchewan inspector found 21 hazards underground and another inspector found 14 on the surface. One inspector wrote the company that the number of dangerous spots is "quite serious."

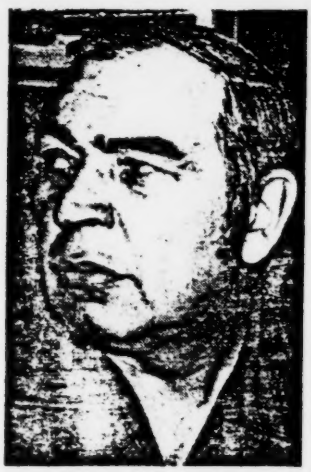
Noise tests last year showed many more Flin Flon workers will go deaf unless noise levels are reduced dramatically. While 85 decibels is the Steelworkers' goal, levels were as high as 119 in the converters, 114 in another plant, 96 in the powerhouse and 112 in the smelter.

Webber says the zinc plant is the "most antiquated in North America." In the plant zinc concentrate that has been separated from lead and copper in the ore is roasted and purified. Zinc in a liquid solution sits in tanks while electric current is passed through it.

In bargaining later this year the Steelworkers will seek substantial improvements in their contract safety rights, says Webber. The safety committee was impressed with recent breakthroughs won by the union at Inco, to provide training in industrial hygiene for employees, inspections and worker-inspectors paid by the company.

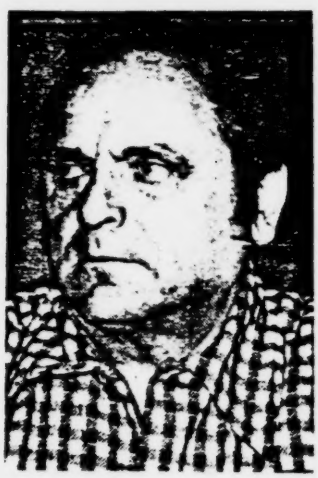
Steve Hamon, the local president, doesn't buy company complaints that it can't afford safety improvements. He points out that the annual report shows HBM and S has loaned $857,000 in interest-free money to top executives to buy houses in Toronto.

PHYLLIS MacKENZIE



CHARLES ZIMMERMAN

WALTER PROKOPETZ



DON STRIJAK

TABLES OF CONTENTS

		Page
1.	INTRODUCTION	1
2.	ENVIRONMENTAL CHARACTERISTICS	1
3.	SOURCES AND DISPERSION OF POLLUTANTS	2
4.	ENVIRONMENTAL MONITORING PROGRAM	3
5.	STACK EMISSIONS	3
6.	AMBIENT SULFUR DIOXIDE LEVELS	5
7.	HIGH-VOLUME AIR SAMPLING	6
8.	HEAVY METALS DEPOSITION (SNOW STUDIES)	7
9.	EFFECTS ON VEGETATION	9
10.	EFFECTS ON SMALL MAMMALS	11
11.	EFFECTS ON FISH	13
12.	TAILINGS EFFLUENT: Effect on Schist Lake System	15
13.	DRINKING WATER	16
14.	CONCLUSIONS	19
15.	BIBLIOGRAPHY	21
16.	ACKNOWLEDGEMENTS	23
	TABLES	
	APPENDIX Clean Environment Commission Order 899VO Tables and Figures	

1. INTRODUCTION

This chapter describes the general environment of the Flin Flon area and identifies those environmental factors which might have an effect on human health.

This work was accomplished by reviewing published and unpublished reports and documents which were available from the various sources and included: sections of the Manitoba Environmental Management Division (EMD) of the Department of Environment and Workplace Safety and Health, the Clean Environment Commission (CEC), the Fresh Water Institute, and Hudson Bay Mining and Smelting Company Limited (HBM&S).

2. ENVIRONMENTAL CHARACTERISTICS

Flin Flon, a small city of approximately 3,500 residents, is situated on the Manitoba-Saskatchewan border about 700 km NNW of Winnipeg. Ross Lake is located in the middle of the city forming a natural division between its eastern and western parts.

Hudson Bay Mining and Smelting Company Limited (HBM&S) is the major employer in the area. The company has been operating a base-metal smelter and mines in the Flin Flon area since 1930. In the smelter, zinc, copper and other metals are extracted from native ores. The consequence of this process is the emission of heavy metals and sulfur dioxide into the general environment of the Flin Flon area. Presently, the main source of the aerial emission is the 250 m stack. It was erected in 1974 to replace two shorter stacks which had been built at the time of the construction of the smelter (Figures 2-1 and 2-2 show the location of Flin Flon in Manitoba and the position of the smelter relative to the town). The tailings pond, 1 km west of the stack, is located in Saskatchewan on the western limit of the city. Under certain conditions this could be another source of heavy metal deposition.

The western part of the city includes the HBM&S mining/smelting complex, downtown Flin Flon and part of Hapnot and Louis Lakes which lie in Saskatchewan. This area could receive emission from the stack when the winds are from the west or northwest and conditions are right for a descending plume.

East of Ross Lake, the city extends for 3 km in a north-south direction. The eastern part of the city can be divided into a southern and northern part. The southern part, lying east of the smelter, is 3 km from the stack at the most eastern point. The northern part of east Flin Flon is northeast of the smelter. Its most distant point is 4 km from the stack.

Channing is a small village 3 km southeast of Flin Flon on the north west arm of Schist Lake. Another community of interest in this study

is Creighton, population 2,000, lying 3 km west of the stack in the Province of Saskatchewan.

In Flin Flon the average daily temperature varies from 18 degree Celsius in July to -24 degree Celsius in January. The average annual precipitation is 456 mm with about half of it occurring between June and September. Winds prevail 95 percent of the time with an average annual speed of 11.1 km/hr. The dominant directions are from the NW to the NE. Since most of the city is situated NE to SE of the smelter, it could be affected by emission from the smelter when winds are in that direction. According to Environment Canada this condition prevails 34 percent of the time (Table 2-2).

Most of the Flin Flon area lies in the Canadian Shield. Because this area has little surface soil, the deposited emissions are not buffered to the extent that they would be if there was plenty of surface soil. The area is underlaid by stable, insoluble rock formations. This rock does not weather appreciably and hence does not contribute significantly to heavy metal accumulation in the environment. At Lake Athapapuskow (30 km south of Flin Flon) the Shield gives way to the limestone of the Manitoba Lowlands.

3. SOURCES AND DISPERSION OF POLLUTANTS

The smelting operations produce three types of waste; tailings, sulfur dioxide, and heavy metal particulates. Emissions from the smelter were affected by two major technological developments. Firstly, a new 250 m stack was erected in 1974 to replace two shorter stacks (69 m and 53 m). Thus, pollutants are discharged from a higher altitude resulting in a greater area of dispersion and a reduction of in-town pollution. Secondly, a new electrostatic precipitator, installed in 1982, substantially reduced particulate emission.

In the process the ore is crushed, and the metals are separated from the rest of the ore in flotation tanks. The concentrate is skimmed from the top and waste is discharged to the tailings pond (Flin Flon Lake) west of the HBM&S complex. Waste water containing various chemicals is also discharged to the tailings pond. Winter freezing dries the suface of the pond leaving a powder which may be picked up by winds and distributed over the area. In addition, aqueous effluents bearing heavy metals not extracted in the treatment process are discharged into the tailings pond. The overflow flows into Flin Flon Creek which is connected to Ross Lake and Schist Lake water system.

Most of the sulfure dioxide, which is produced from the combustion of sulfur containing ores, leaves the complex through the main stack. However, some sulfur dioxide is released from the process buildings, primarily from the anode casting, fuming furnace, and other parts of the HBM&S operation which are not connected to the main stack. These emissions may have a greater effect on the sulfur dioxide level in the city than the main stack emission. The sulfur dioxide from the 250 m

stack should not affect the city unless adverse atmospheric conditions cause the plume to be directed downwards. Conversely, under normal conditions, sulfur dioxide from the stack passes well over the city.

Metal particulate matter which has not been collected by the baghouse or the precipitator, as well as metal fumes which solidify as particulates, enter the stack and are similarly discharged to the environment. Because of their mass, the heavy metal particulates may settle to the ground sooner than the sulfur dioxide. This particulate matter containing copper (Cu), lead (Pb), arsenic (As), cadmium (Cd), iron (Fe), mercury (Hg) and other metals will then accumulate in the environment.

4. ENVIRONMENTAL MONITORING PROGRAMS

Emissions leaving the main stack at HBM&S are monitored on a regular basis. The company is required by the Clean Environment Commission Order 899VO to carry out stack sampling every year. The sulfur dioxide and particulate emission data must be routinely submitted to the Environmental Management Division (EMD). In addition, on a monthly basis, the company estimates the amount of pollutant leaving the complex by mass balance calculations. In this method the total sulfur dioxide emission is calculated by first determining the amount of sulfur in the ore processed. From this, the amount of sulfur lost as slag or residues and the amount used internally is subtracted. The remainder is assumed to be leaving the stack as sulfur dioxide. The amount of particulate matter lost through the stack is similarly calculated by using the amount of ore crushed, the efficiency of the collecting units, and the quantity of metals produced.

EMD has initiated several programs aimed at monitoring the level of sulfur dioxide and heavy metal pollutants in the Flin Flon environment. There are five sulfur dioxide monitoring stations (see Figure 4-1) in the area; three of which are operated by HBM&S (Creighton, Phantom Lake and Hudson Bay Airport Terminal) and two by EMD (Channing and City Hall). These stations continuously monitor the ambient air, producing hourly averages of sulfur dioxide levels.

In addition, studies have been carried out to determine heavy metal accumulation in snow, soil, vegetation, tissue of small mammals, fish flesh as well as the metal content of water and sediment of surface waters in the area.

5. STACK EMISSIONS

The 250 m stack at HBM&S has been identified as the major potential source of pollution for both sulfur dioxide and heavy metal particulates. In 1981, the Clean Environment Commission (CEC) (Order 899VO, Appendix 17.1) limited the stack emissions. The Order requires the company to monitor the emissions using stack sampling and mass

balance calculations and forward the results to EMD. Results of stack sampling are shown in Table 5-2 to 5-10.

Table 5-1 and Figure 5-1 show the average daily emissions of sulfur dioxide estimated by the mass balance calculation. Sulfur dioxide emissions did not vary greatly between 1950 and 1985; the highest being 872 tons per day (1955-59) and the lowest 724 tons per day (1976). Since stack sampling data are only available after 1981, the mass balance calculated estimates of sulfure dioxide emissions from 1950 to 1980 cannot be confirmed by a second method of monitoring. As well, company data for 1983 stack sampling was not available when this report was completed. For ease of interpretation the mass balance calculations and the stack sampling data between 1981 and 1985 are graphically displayed in Figure 5-2 (for sulfur dioxide) and Figure 5-3 (for particulate matter).

Figure 5-2 shows that mass balance calculations and stack sampling estimates for sulfur dioxide do not correspond except for 1981. This may be in part because stack sampling reflects emission on only three consecutive days in September of each year. Since the stack sampling method does not take into consideration the fluctuating production volumes and ore quality over a long period, the mass balance calculations are probably a more reliable estimate of emissions. While stack sampling estimates show a decrease in sulfur dioxide emissions since 1981, the mass balance calculations show an increase of emissions. The 1984 mass balance calculations show that the sulfur dioxide emissions were approaching the limit of 885 tons per day. Data for 1985 stack sampling was not available when this report was drawn up.

A further reason why stack sampling may underestimate the total emission of sulfur dioxide from the HBM&S complex is because the fuming furnace and the anode casting are not connected to the main stack.

Effective in September 1983, the particulate emission was limited to 5 tons per day by the CEC Order 899VO. Figure 5-3 shows that emission of particulate matter estimated by mass balance calculations, declined rapidly between 1981 (annual average 43.4 tons per day) and 1983 (11.5 tons per day) and then increased to 13.9 tons per day in 1985. The trend of emissions estimated by stack sampling was similar to that obtained by mass balance calculations. Contrary to the CEC Order, the maximum level of the total particulate matter emitted has been continuously exceeded since 1983 (see Figure 5-3).

Tables 5-4, 5-6 and 5-9 show the composition of particulate matter emitted through the stack. Zinc is the main component of the particulates (43% in 1981, 22% in 1982 and 25% in 1983) followed by iron (9%, 3%, 6% respectively), lead (4%, 7%, 3%, respectively) and other metals. Mercury could also be emitted through the stack.

Testing methods are presently not available to determine the quantity of mercury released through the stack or present in the air.

It appears that estimates of emissions obtained by stack sampling which are actual test results and by mass balance calculations which are calculated monthly are less comparable for sulfur dioxide than for total particulate matter. This might be due to a greater day to day variability of emission for sulfur dioxide than for total particulate matter. Figure 5-4 shows this variation which is associated with stack sampling and mass balance calculation. All data must be interpreted carefully when attempting to determine the total environmental loading from the complex. When stack sampling is conducted, a complete inventory of product flow must be obtained.

6. AMBIENT SULFUR DIOXIDE LEVELS

Before the construction of the 250 m stack in 1974, ambient sulfur dioxide levels were frequently high within the City of Flin Flon. The current one hour average maximum acceptable level (MAL) concentration for sulfur dioxide is 0.34 parts per million (ppm). Presently, emissions from the 250 m stack usually flow above the city. The number of excursions of the sulfur dioxide concentration above the one hour average MAL has decreased since 1974. The reduction of the frequency of these excursions is demonstrated in Table 6-1.

EMD has been operating two ambient sulfur dioxide monitoring stations in the Flin Flon area since 1973. HBM&S began monitoring at three additional sites in 1976. The monitoring stations produce hourly averages which are tabulated monthly. Effective monitoring time varies from station to station depending on the maintenance of the monitoring equipment. In Table 6-1, data from stations in Channing and Flin Flon City Hall have been adjusted to reflect monitoring results for 100 percent of the time. This adjustment was done because in 1973 and 1974, data was available for less than 20 percent of total time. After adjusting for effective operating time, the decrease in the number of excursions since 1974 became much more apparent. Although the frequency of excursions decreased significantly, the magnitude of the larger excursions has remained constant. When adverse atmospheric conditions cause the plume to be directed downwards, the new stack appears ineffective in providing dispersion. This decrease in the number of exceedences has occurred in light of an increase in volume of ore processed since 1974 (Table 6-2).

Figure 6-2 shows that annual ambient sulfur dioxide maximum levels in Flin Flon are significantly higher than those in Winnipeg. The 99th percentile values (the level which is exceeded only 1 percent of the time) also demonstrate that sulfur dioxide could be higher in Flin Flon than in Winnipeg.

Figure 6-3 (not adjusted to 100 percent effective monitoring) shows the number of MAL exceedences each year at the Channing and City Hall

stations. Again, 1975 shows a great decrease in frequency of exceedences.

Since there are 8,760 hours in a year, the number of hours when the acceptable limits were exceeded, seems insignificant. However, it must be considered that sulfur dioxide excursions will only occur at a particular station when the wind is blowing in that direction. Because the prevailing winds are from the NW 17 percent of the time in a given year (as documented by Environment Canada), the 358 excursions at city hall represent 1/4 of the time when the wind is blowing in that direction. Although this is not an exact figure it does represent the best interpretation of the data.

All monitoring stations in the Flin Flon area are located SE to SW from the smelter. Hence we have no data on ambient sulfur dioxide levels for areas of the city which are not SE to SW from the smelter. Figure 6-1 and Figure 6-2 show that only one of the five monitoring stations is located in the more highly populated areas of the city. The area of Flin Flon east of Ross Lake is not monitored for sulfur dioxide levels.

In summary, ambient sulfur dioxide levels in the Flin Flon area are higher than those of an urban area such as Winnipeg. Although there has been a great decrease in the frequency of excursions above one hour average MAL since 1974, many excursions still occur. A high proportion of the excursions are probably not detected by the five monitoring stations because of their locations. This is further complicated by the amount of time the stations are not working. Additional stations should be added to the network if complete coverage of inhabited areas of Flin Flon is desired.

7. HIGH-VOLUME AIR SAMPLING

The purpose of high-volume air sampling is to determine the concentration of heavy metals in ambient air. Samples are collected over a 24 hour time period. High-volume data generated in 1977 from three stations in Flin Flon and one in Winnipeg show the levels of ambient airborne heavy metals and dust in these areas. Flin Flon represents a small urban area with a specific heavy metal industry while Winnipeg represents a large urban area with a wide variety of sources.

The three Flin Flon monitoring stations are 0.9 km, 2.1 km and 2.4 km away from the smelter in the SE direction. Although a gradient might have been expected between these sites, examination of the data reveals no such gradient. While the levels of heavy metals were usually highest close to the smelter (0.9 km), levels at the most distant station were at times higher than those at the intermediate station. According to Strachan (EMD, personal communication), levels detected in Flin Flon were to some extent created by local sources other than the smelters. This is probably the reason why high volume measurements did not indicate a gradient with respect to the smelter.

It can be seen from Table 7-1 that Total Suspended Particulate (TSP) were higher in Winnipeg than in Flin Flon, although in both areas they were below the Manitoba Provincial objective (120 ug/m^3). Similarly, lead levels were higher in Winnipeg than in Flin Flon. While zinc was not measured, copper concentrations in Flin Flon were six times greater than in Winnipeg, and iron was approximately the same in both locations. Cadmium and arsenic were reported in Flin Flon but were below the detectable level in Winnipeg. Lead was slightly higher in Winnipeg than in Flin Flon. This was attributed to automobile emissions and local foundries in Winnipeg.

8. HEAVY METAL DEPOSITION (SNOW STUDIES)

Snow studies, used to determine the deposition of heavy metals in the snow column, have been performed in the Flin Flon area by several investigators. Franzin et al (1979) sampled snow on lakes in Manitoba and Saskatchewan during 1976 and 1977. The monitoring sites described in the chapter on Environmental Monitoring Programs (Table 4-1) were sampled by Wotton et al in 1979 and 1980, and by Phillips et al in 1981-1983. Shewchuk sampled various locations in Manitoba and Saskatchewan during 1982 and 1983.

All studies agreed that significant amounts of zinc, lead, copper, other metals and arsenic were deposited to the snow from the atmospheric fallout. The HBM&S smelter has been identified as the probable source since the concentration of heavy metals decreased with the distance from the smelter.

The data collected by Franzin in 1976 "are very irregular probably due to sampling error". Sampling was done "too near to lake shores where snow accumulated and where there was a high availability of local particulate material". According to Franzin, this error was eliminated in 1977 by using a systematic sampling procedure. Only the 1977 data was used in this report (Franzin et al, 1979). Table 8-1 demonstrates gradients in deposition for Fe, Pb, As, Cd, Cu and Zn in eight directions from the smelter. Table 8-2 shows calculated mass of metals deposited on various lakes during an 85 day period. Cliff Lake, for example, received about 733 mg of zinc per litre of snow during a three month period in 1977. From that information it is calculated that 1,563 kg of zinc fell on the total surface of the lake in that time (Franzin 1979, Table 8-1).

Franzin concluded on the basis of comparison of his findings with those for other areas, that the Flin Flon smelter is a significant source of airborne Zn, Cd, Pb, As, and Cu for the environment (Franzin et al, 1979).

Hogan and Wotton (1980) also found that with an increasing distance from the smelter, the concentration of heavy metals and arsenic in snow decreased (see Tables 8-3 and 8-4). The highest accumulation of Pb, Cu, Fe and As in snow was at the site close to the smelter (5.8 km).

Unfortunately, because the methodology for the snow studies was not standardized, it was impossible to compare these data to other snow studies.

Phillips et al (1983) prepared the most detailed snow study report (Tables 8-5 to 8-9). It was found that amounts of Zn, Cu, Fe and Pb in snow decreased with the distance from the smelter by an inverse curvilinear relationship or power curve. Phillips found that the deposition of zinc, copper, iron, lead and cadmium decreased substantially from the winter of 1982 to the winter of 1983. This is attributed to the installation of the electrostatic precipitator in November 1982. It is estimated that in comparison with 1982 levels, there was in 1983 a 5 percent decrease in the deposition of zinc, a 10 percent decrease of cadmium and a 20 percent decrease of copper, iron and lead. According to Phillips (personal communication), the 1984 and 1985 data show much lower deposition than the 1982 data, although not as low as 1983 when the lowest deposition was recorded. It should be noted that the 1985 levels (for zinc for example) were nearly twice as high as the 1983 levels. We must keep in mind, however, that the 1985 levels were still 10 times lower than the 1982 levels. The stack emission data supplied by HBM&S show that the rate of 6.5 tons of particulates per day in 1983 has risen to 13.15 tons per day in 1984. This is consistent with the findings of Phillips (personal communication). It is possible (Jackson, personal communication) that the old precipitator, which was put in series with the newly installed (1982) precipitator, was beginning to deteriorate. The old precipitator was not diminishing the load on the new precipitator as it did in 1983. This would overload the new precipitator and increase emissions of heavy metal particulates.

Shewchuk (Saskatchewan Research Council) prepared two reports dealing with heavy metals in snow near Flin Flon. As the data in these reports are not converted to mg/m^2 from mg/l, results from these two reports can not be compared. Phillips (personal communication) confirmed that these reports demonstrate a gradient of deposition. In addition it was found that the levels of heavy metals were much higher in Creighton than in other areas of Saskatchewan. Comparisons between different sites in the same year cannot be made. This is because different amounts of snowfall at the sites would affect the concentration when it is expressed as mg/l. Shewchuk's third report (unpublished) does allow for comparison since these measurements are expressed as mg/m^2. According to Phillips (personal communication), the third report concluded that the electrostatic precipitator had decreased the deposition of heavy metals.

The snow studies have demonstrated that the deposition of heavy metals

decreases with the distance from the smelter. Copper, lead, iron, cadmium, zinc and arsenic have been shown to be present in snow columns as a result of aerial deposition. The deposition decreased after the new precipitator had been installed. The recently observed increase in the deposition could be attributed to a reduced efficiency of the present system (electrostatic precipitator).

9. EFFECTS ON VEGETATION

The effects of smelter emissions on vegetation in the Flin Flon area have been documented by EMD reports. Hogan and Wotton (1980) report that:

> "Smelting activities in the Flin Flon area have lead to a general decline in the forest community in the immediate vicinity of the smelter. A similar decline has been observed in other regions of North America and is generally attributed to the combined effects of sulfur dioxide and heavy metal particulate."

There has not been a significant effect on the presence or absence of trees and shrubs at distances greater than 5 km from the smelter. Abundance and species diversity of mosses and lichens were much reduced at sites closest to the smelter (Figures 9-1 and 9-2). These lower plants are known to be affected by sulfur dioxide and metal deposition.

Abundance of higher plants has not been affected but metal accumulation in these plants has occurred. Table 9-1 shows a gradient in metal content of jack pine cones with the distance from the smelter. Similar gradients were noted in foliage of various plant species. Smelter emissions did not appear to affect the germination capacity of the jack pine conifer seeds (Table 9-2).

One effect of particular concern is the accumulation of metals in the soil (Figure 9-3). Hogan and Wotton (1980) suggest that this accumulation may influence the microbial decomposition of organic materials. A build up of organic materials can in turn result in a reduction in nutrient release and ultimately affect the productivity of the site.

Vegetation studies have included the monitoring of blueberry plants in the area. Since lead and mercury are part of the emissions from the stack, their presence was found in the Flin Flon environment. Samples of blueberry plants taken by the Northern Forest Research Center, Edmonton, in 1978, indicated that the concentrations of lead and mercury in blueberry plants in the Flin Flon area were higher than expected. This prompted EMD to conduct a research survey between 1979 and 1982, resulting in two published reports (1979 and 1983).

The methods and site selections used in both reports were the same except that in 1983 two sites were added north of Flin Flon. The

survey included the determination of lead and mercury levels in berries, leaves, stems and roots of blueberry plants. In addition, the top soil was tested for lead and mercury.

One problem encountered in the study was the determination of the metal to berry weight ratio. Wet weight values are not consistent because they depend on atmospheric conditions. However, they are desirable values for they represent the "as eaten" condition. Dry weight values also pose a problem for mercury analysis, because mercury may be driven off as a vapour if heat is used to dry the berries. In this study, the wet weight values were determined and converted to a dry weight concentration, thus accounting for the different moisture concentration between samples. The standardized wet weight concentrations were then calculated by multiplying the dry weight concentrations by 0.3, a factor expressing an average of 70 percent water content of the blueberries. These standardized wet weight values allow for comparison between sites. This method of reporting the data attempts to control the variability normally associated with wet weight concentrations.

Although the results of mercury analyses (Table 9-3) were inconsistent, certain trends were evident. The berries accumulated much less mercury than leaves, stems or roots of the plant. The soil, having been subject to accumulation over a large number of years, had by far the highest level of mercury (as high as 24 ug/g: EMD, 1983). It was found that as the distance from the smelter increased, mercury content of blueberry plants and of soil decreased. This gradient was not demonstrated for the berries. It cannot be concluded whether or not washing the berries reduced the mercury content. It was concluded however, that mercury concentration in berries collected from some areas near Flin Flon were in excess of background levels (Cranberry Portage, 38.9 km ESE from the smelter). While there is no firmly established acceptable limit for mercury content in fresh blueberries, 0.05 ug/g concentration has been suggested as a guideline for dry weight by the Food Directorate in Ottawa.

Table 9-4 shows the results of the lead analyses. A definite correlation was noted between the distance from the smelter and the levels of lead in all plant components. The levels were highest near the smelter and decreased to background levels as the distance from the smelter increased. The levels of lead were lowest in the berries and highest in the soil. Washing of the berries may have removed some of the lead from the surface of the berries.

While the 1982 data show a decrease in lead levels in the blueberry plant components, the mercury levels were similar to those in previous years. On the average, the lead levels were reduced by up to 70 percent in 1982 in comparison with the two previous years. It was noted that the smelter was shut down during July and August of 1982. This may be the reason for lower lead levels in berries in that year.

The electrostatic precipitator, installed by HBM&S, did not come into full use until November 1982, but emissions were already decreased significantly by other various adjustments to the process. The decreased emission rate would also have contributed to the lower levels of lead for 1982. This would indicate that levels of lead in the blueberry plants represented current exposure rather than the uptake of accumulated lead from soil.

No blueberry studies were carried out in 1983 or 1984 but a survey was carried out in August 1985. Phillip's (1983) snow studies show that there was a great decrease in lead deposition to snow for the year 1983. This was definitely attributed to the precipitator.

In 1984, the Food Directorate reviewed the blueberry data. It was concluded that the mercury levels were only slightly higher than background and that they did not pose a health hazard. The lead levels, however, were reported as being at least ten times higher than normal background levels. The following recommendations were made by the Federal Chemical Evaluation Division of the Food Directorate:

> "When consumed as part of a balanced diet, blueberries containing such levels of lead would still not be considered to pose a health hazard to the consumer. However, such blueberries could contribute a disproportionately high amount to the total lead intake compared to other similar foods. In view of its toxic potential, it is of course desirable to minimize the intake of lead from all sources to the lowest possible level and, for this reason, it is suggested that such blueberries be eaten in moderation only."

In conclusion, vegetation studies have demonstrated that there is a gradient of metal deposition. The absence of lichens near Flin Flon adds to this conclusion. Following the recommendation of the Food Directorate (1984), when berries are picked near the Smelter, they should be washed and consumed in moderation.

10. EFFECTS ON SMALL MAMMALS

In an attempt to assess the effects of the HBM&S smelter emissions on small mammals, EMD trapped and analyzed blood and tissue of deer mice and red backed voles in the Flin Flon area. Results of the analyses of blood samples, obtained from deer mice during the summers of 1977, 1979 and 1981, were pooled according to the five distinct zones. Heavy metal analyses of tissue were carried out for deer mice trapped at five locations within the above mentioned zones in 1981 and 1982. Table 10-1 shows trapping locations and zone designations. Since there were few red backed voles trapped, there was not enough blood or tissue available for meaningful analyses.

Immediately after being removed from the traps, the mice were anesthetized and a sample of blood was collected from the orbital

sinus. The hemoglobin concentration (g/100 ml), the packed cell volume or hematocrit (percent) and the plasma protein content were measured. The animals were then sacrificed and frozen for determination of the heavy metal content of the carcass and hide.

The blood data show that hemoglobin concentrations were highest in deer mice trapped closest to the smelter (Table 10-2). The distance at which the hemoglobin concentrations fell to background levels were estimated to be 40 km from the stack. All hemoglobin concentrations, even those closest to the smelter, were within the physiologically normal range. When data were pooled, the mean values were adjusted for both the plasma protein levels and for the presence or absence of parasitic larvae under the skin. This was necessary because a number of mice trapped were infested by fly larvae which could significantly lower the hemoglobin levels. In addition, because hemoglobin concentration is significantly correlated to plasma protein levels, some of the hemoglobin levels may be artificially high due to dehydration. These factors were taken into account in adjusting the mean.

Table 10-2 shows the mean corpuscular hemoglobin concentration (MCHC) values for mice collected. The MCHC was highest near the smelter and decreased with the distance. However, this gradient was not statistically significant. On the other hand, the hemoglobin concentrations (g/100 ml) were also highest close to the smelter and decreased with distance. This gradient is statistically significant. Data in Table 10-2 are for zones, not for individual sampling sites. A 1980 submission to the Manitoba Clean Environment Commission by Kucera contains mean hemoglobin data for individual sites. These data are presented in Table 10-5. The data used in the 1980 report were pooled with data collected in subsequent years to form part of the more comprehensive 1983 Kucera report.

Table 10-3 shows that tissue levels of Cu, As, and Pb were highest in deer mice trapped close to the smelter, and decreased with distance. The hide zinc data are less conclusive as to the gradient. Carcass cobalt levels were also determined in the study. Since cobalt represents only 0.005 percent of the particulate emissions (1984 HBM&S Emission Report), this low level of emission was not expected to affect tissue level. Cobalt tissue levels did not change with the distance from the smelter.

Overall, the tissue analyses data indicate that copper, arsenic and lead accumulated in the tissues of deer mice which had been exposed to a heavy metal contaminated environment. The red backed vole, a common boreal forest mammal, was very scarce at plots up to 37 km from the smelter. It was suggested (Kucera, 1983) that the herbivorous diet of the red backed vole, as opposed to the granivorous diet of the deer mice, would involve larger intakes of accumulated heavy metals. Kucera's (1983) findings, reproduced in Table 10-4, show the ratio of red backed voles to deer mice trapped in each zone. The table shows

that the vole population gradually increased with the distance from the smelter.

Kucera suggested that the vole's absence near Flin Flon may be due to heavy metals intake rather than to sulfur dioxide emissions or other ecological factors (type of forest, dietary requirements, etc.). In a similar study, the vole was not trapped near Thompson. Trapping sites were considered far enough from the human settlement for these not to affect the vole populations. The area with the smallest vole population

Kucera suggested that the vole's absence near Flin Flon may be due to heavy metals intake rather than to sulfur dioxide emissions or other ecological factors (type of forest, dietary requirements, etc.). In a similar study, the vole was not trapped near Thompson. Trapping sites were considered far enough from the human settlement for these not to affect the vole populations. The area with the smallest vole population overlaps with the area in which the deer mice had elevated concentrations of metals. In some cases, because of their diet, the amount of metal intake may have been sufficient to kill the voles. However, no feeding trials were conducted to either confirm or reject this possibility.

11. EFFECT ON FISH POPULATIONS AND METAL CONTENT OF FISH TISSUES

Several studies have been conducted on the effects of metals on fish in the Flin Flon area. VanLoon and Beamish (1977) of the University of Toronto and the Federal Department of Fisheries and Environment respectively, studied fish populations in 31 lakes near Flin Flon. There were no fish tissue analyses done in this study. Wilson (1984) of EMD determined levels of heavy metals in fish flesh from Trout Lake and Cliff Lake. Klavercamp (1986), of the Freshwater Institute in Winnipeg studied heavy metal content in muscle and liver tissue of fish taken from 13 lakes near Flin Flon, 4 of which were in Saskatchewan.

In the study by Wilson (1984), 92 fish from Trout Lake and 35 fish from Cliff Lake were captured and analyzed. Results of the analyses performed at the W. M. Ward Technical Services Laboratory are presented in Tables 11-1 to 11-3. It was found that although the mean mercury concentrations of the muscle tissue were higher in fish from Trout Lake than Cliff Lake, of the 3 species studied (pickerel, pike, lake whitefish), only lake whitefish in Trout Lake showed significantly higher mercury levels. Wilson concluded that these elevated levels in whitefish were not sufficient to indicate differential loading of the lake with mercury because these results were not consistent with the findings for the two other species.

Klavercamp (1986) found lower mercury levels in fish from Manitoba lakes close to Flin Flon than in fish from the 4 Saskatchewan lakes (located 60-70 km west of the smelter). In addition, fish from Manitoba lakes had twice the selenium levels. Similar effects were found by Speyer (1980) in northern pike at Noranda. It has been suggested that the higher selenium concentrations which are due to the

aerial deposition of selenium, reduce the mercury levels in fish by some biochemical mechanisms (Klavercamp, personal communication).

Wilson (1984) found that the walleye in Cliff Lake had higher concentrations of arsenic than in Trout Lake. The reverse was found to be true for whitefish. In support of the walleye results the geographical location of Cliff Lake with respect to Flin Flon suggested that the deposition on Cliff Lake would be higher and consequently it would have higher arsenic levels. This in effect would confirm the gradient deposition of metals from the stack. Wilson (1984) however, concluded that arsenic levels in Cliff and Trout Lakes were derived primarily from underlying geological sources and that these sources would affect the arsenic levels in fish more than aerial deposition.

Wilson (1984) also reported higher copper levels in Cliff Lake whitefish, but not in other fish species. Klavercamp's (1986) preliminary results are not consistent with the hypothesis that copper is concentrated in whitefish to a significant degree.

Lead, cadmium and nickel were not detected in fish flesh in significant amounts in either Trout or Cliff Lake (Wilson, 1984). While Klavercamp's study confirmed that these metals were not concentrated in the muscle tissue, it found that cadmium was concentrated in the liver tissue of fish in the Flin Flon area.

Wilson (1984) found significantly elevated levels of zinc in tissue of whitefish and northern pike in Cliff Lake. This observation is consistent with the results of the analysis of arsenic concentrations in walleye. Klavercamp (1986) reviewed both top and bottom predators and concluded that bottom feeding suckers had significantly higher zinc tissue concentration than top feeders.

Hamell Lake, which is closer to Flin Flon than Cliff and Trout Lakes, was found to be highly affected by metals. VanLoon and Beamish (1977) concluded that the total catch in Hamell Lake was "below average when compared with other nearby lakes with lower heavy metals content". Klavercamp (1986) reported that Hamell Lake had higher metal levels than most lakes in the Flin Flon area. Thompson Lake (20 km east of the smelter) for example, had much lower metal levels and a higher fish count than Hamell Lake. Klavercamp (personal communication) found that levels of a metal binding protein were 2 - 4 times higher in Hamell Lake fish than in Thompson Lake fish. It is suggested that this protein provides protection against the toxicity of metals such as zinc. This need for the extra production of the metal binding protein in Hamell Lake fish may have consumed large amounts of energy, and in turn sacrificed growth and reproduction (Klavercamp, personal communication). VanLoon and Beamish (1977), referring to fish from Hamell Lake, stated that "fish were more tolerant of these high zinc concentrations than would be expected on the basis of the response of fish...to similar concentrations of the zinc in laboratory toxicity

tests". This additional tolerance might be due to production of the excess metal binding protein (Klavercamp, personal communication).

In conclusion, it appears that fish in lakes impacted by aerial deposition of heavy metals can be adversely affected particularly with respect to reproduction and growth (VanLoon and Beamish, 1977, Wilson, 1984, Klavercamp, 1986). Production of metal binding proteins may to some extent protect fish from the toxic effects of metals in their environment. Elevated levels of zinc, mercury, selenium, cadmium, arsenic, and copper in the lakes may increase the probability of accumulation of these metals in fish tissue. Klavercamp's (1986) report (in preparation) will further contribute to our understanding of the relationship between metals in lake water and sediment, metal binding proteins in the fish, levels of metals in fish tissue and the toxicity of these metals to the fish.

12. TAILINGS EFFLUENT: EFFECT ON SCHIST LAKE SYSTEM

Overflow from the HBM&S tailings pond enters Flin Flon creek at the north weir. This effluent, containing heavy metals, makes its way down the system to Ross Lake where it is further diluted. Ross Lake flows into the Northwest arm of Schist Lake via Ross Creek (see Figures 2-1 and 2-2). EMD has documented the water quality of the Schist Lake system since 1957.

Ross Lake is nearly devoid of fish because of the high concentration of toxic compounds. It is suggested that fish may occasionally pass through Ross Lake but there may not be sufficient food to sustain life. Benthic organisms are sparse and the diversity low. Williamson (1980) concluded that:

> "Water collected from Ross Creek was acutely toxic to fish. Heavy metal levels in Ross Creek waters were not greatly reduced from values found in discharges over the north weir."

Schist Lake, further down the system, contains pollutants, but the threat to aquatic life is much less severe than in Ross Lake. Hughes (1975) stated that:

> "The metals and other foreign matter present in the waters of the NW arm of Schist Lake may not be present in enough quantity to be acutely toxic but are sufficiently high to affect the reproduction, growth, movement and other aspects of the biology of organisms present."

Lake trout and whitefish are two species which seem to be more sensitive to the effect of pollutants. They were abundant in the past in in the Northwest arm of Schist Lake but are now absent. Although overfishing may have been somewhat responsible, Williamson (1980) concluded that:

"Direct waterborne contamination of heavy metals was probably the greatest contributor to the heavy metal load in the NW arm. Most heavy metals were immobilized in the sediments of the northwest arm via biological and chemical mechanisms supported by nutrient enrichment from sewage discharges. Fish populations may have been undergoing some stress as a result of long term heavy metal contamination of the NW arm."

"Waters receiving drainage containing the north weir discharge did not regain a quality close to natural background conditions until some point between Schist Lake and Lake Athapapuskow."

The quality of water in the Schist Lake system has deteriorated (since 1957) because of effluents containing heavy metals which originate at the north weir (HBM&S tailings pond). This deterioration is greater than what would have been expected from atmospheric deposition of heavy metals alone.

13. DRINKING WATER

The City of Flin Flon receives drinking water from Cliff Lake, a small lake 1 km north of the city. The lake is replenished by a pipeline from the larger Trout Lake situated 4 km NE of Flin Flon. The drinking water for the city is pumped from Cliff Lake, chlorinated, heated during the winter at three heating plants, and then distributed to residents and businesses in the city.

Heavy Metal Content

Prior to the installation of the electrostatic precipitator in the zinc plant (HBM&S) in November 1982, Cliff Lake and Trout Lake were subject to considerable loading with heavy metals (Franzin et al, 1979). "The precipitator has drastically reduced emissions from the plant and thus the fallout onto the lakes was proportionately reduced." Franzin et al (1979) estimated that in 1977, approximately 7,000 kg of zinc, 400 kg of copper, 20 kg of arsenic and 160 kg of lead were deposited on Cliff Lake. It could be assumed that the deposition prior to 1983 was similar.

The large deposition has been handled well by both Cliff and Trout Lake. Drinking water samples from Cliff Lake were sent to the WM Ward Technical Service Laboratory for chemical analysis in 1980 and 1983. All heavy metals were well within the drinking water guidelines as set in Guidelines for Canadian Drinking Water (1978). Although the concentrations of zinc in drinking water was elevated in Flin Flon (0.44 mg/l in 1980) in comparison with Snow Lake or The Pas (0.02 mg/l) the level was much lower than the aesthetic standard for zinc (5.0 mg/l).

As well, levels of cadmium, copper, lead, mercury and iron were low in the Flin Flon drinking water in both 1980 and 1983 (see table 13-1).

An EMD report (Wilson, 1984) dealt with levels of heavy metals in Trout and Cliff Lakes. Results of physical and chemical analyses of water and sediment are shown for both lakes in Table 13-2. It was concluded that:

> "Elevated copper and zinc levels in the water column, sediments and fish muscle tissue of both Trout Lake and Cliff Lake were attributed to aerial deposition from the Hudson Bay Mining and Smelting Co. base metal smelter at Flin Flon."

The evidence that lead, mercury and cadmium in the lakes originate from the smelter was not conclusive. However, leaching of metals from the bedrock to the water column was probably not of major significance (Wilson, 1984).

Most of the heavy metal material deposited to the lakes ends up in the sediments. Wilson (1984) stated:

> "Mean zinc concentrations, like that of copper and lead, were significantly greater in the sediments of Cliff Lake (2922 ug/g) than in sediments of Trout Lake (1502 ug/g). Compared to mean concentration in sediments of an unimpacted lake such as Sherlett (189 ug/g; Beck 1983), levels in both Trout and Cliff Lakes appear indicative of loading."

Although levels of metals in the water column are elevated they are well within the drinking water standards. Sediment appears to have absorbed most of the heavy metal material that has been deposited to the lakes.

Microbiology

The microbiological quality of the Flin Flon drinking water is analyzed weekly. Samples are taken at four sites: Cliff Lake Pumphouse and each of the three heating stations. Analysis which consists of coliform testing and standard plate counts (SPC) is carried out by the Cadham Provincial Laboratory in Winnipeg.

The drinking water samples were consistently late to arrive at the laboratory; most of the samples being in transit for 48 hours or more. The samples must be analyzed within 24 hours of collection because the exponential growth of the bacteria over an extended time period may lead to high plate counts. On the other hand unreliable coliform results may be obtained because of coliform die-off.

Since 1980, the coliform analysis has been consistently negative for all four sites. No data are available for the period prior to 1980. Negative results for coliform testing suggest that Cliff and Trout Lakes received little human or animal fecal contamination. Public

Health-Sanitation regulation P210-R3 Division XI entitled, Sanitary Areas, in Certain Portions of the Province, section 172 designates Trout and Cliff Lakes as sanitary areas. No human excrement, garbage, carrion or any other substance that may pollute the water may be deposited into, on or near the sanitary areas. It would appear that the quality of water in Trout and Cliff Lakes has been preserved by this legislation.

Although the coliform counts are low, the SPC levels for samples taken at the heating stations are high.

An information sheet released by EMD entitled Standard Plate Count Analysis - Municipal Finished Water Samples, states that:

> 1. The SPC analysis provides an index of the level of the general bacterial population in a water sample and is, therefore, a good indicator of the general sanitary quality of the water.
>
> 2. Coliform analytical results may not be reliable for water samples with an SPC greater than 500/ml.
>
> 3. An SPC level of 500/ml should be considered as an objective for finished water. Operators should be encouraged to meet this objective.

The SPC level in the Flin Flon drinking water were consistently high for three of the four sampling sites. The Cliff Lake Pumphouse Station samples were analyzed for coliforms only. There is usually no SPC done for this site.

The suggested guidelines for finished drinking water of 500 bacteria/ml of water was exceeded on a regular basis for water samples taken at heating plants Two and Three. Heating Plant One often had higher SPC's than other plants. The highest SPC was recorded in 1981 when the SPC was first introduced as a routine analysis: water collected from taps in homes and a school in Flin Flon had SPC's of greater than 3000 bacteria/ml of water.

As a comparison, the results of the analysis of drinking water in Thompson were reviewed. The coliform results from Thompson were consistently negative. The SPC's in Thompson were generally lower than those in Flin Flon: with few exceptions they were less than 10 bacteria/ml. The prompt (next day) delivery of the Thompson samples to the laboratory contributed to the low plate counts at Thompson. In addition to transportation time of the sample, the residual chlorine levels must also be considered.

Section 59(4) of Regulation P210-R3 states that the free chlorine residual should not be lower than 0.5 mg/l after a minimum contact time of chlorine with water of 20 minutes. In Flin Flon, residual chlorine

levels averaged below 0.2 mg/l between 1981-1985. In Thompson, the free chlorine residual in water was higher than those in Flin Flon (averaging near 0.3 mg/l).

The microbiological analysis of drinking water in Flin Flon should be performed with utmost efficiency since the sewage pipes and the water distribution pipes are very old and may leak (Rocan, personal communication). Since they are in the same utilidoors, there is a danger of contamination of drinking water in Flin Flon.

It is suggested that the reason high SPC's should be investigated. Speical effort should be made to deliver water samples to the Cadham Laboratory within 48 hours from the time of collection.

Generally, the quality of the Flin Flon drinking water is good, since the levels of chemical elements are within the standards and the coliform bacteria counts are low. However, there could be a potential problem if the level of heavy metals continues to rise as loading of surface waters continues. The possibility for cross-contamination between sewage and drinking water means that the bacterial analysis of the water should be performed very carefully.

The microbiological reports for August, 1985 have shown an improved water quality.

14. CONCLUSIONS

The HBM&S smelter in Flin Flon is a source of environmental pollution consisting of sulfur dioxide and particulates.

The new stack (1974) provides more dispersion for sulfur dioxide than the previous shorter stacks. There have been periods of elevated sulfur dioxide concentrations in the city during the late 1970's and 1980's but such excursions have been less frequent since 1974. However, the magnitude of the larger excursions have remained relatively constant.

Snow studies have demonstrated a gradient of decreased deposition of Zn, Fe, Cu, Cd and Pb with an increasing distance from the smelter. The gradient is also demonstrated for concentration of heavy metals in vegetation, population dispersion of lower plants and hemoglobin values in deer mice (Table 14-1). Snow study data correlated well with stack emission data; increased emission rates resulted in increased deposition on snow.

The electrostatic precipitator and several other adjustments made to the collection system during 1982 have significantly reduced the particulate emission rate. The particulate emission rate has slightly increased since 1983. The 1984 and 1985 data indicate that the CEC

particulate emission limit of 6 tons per day has been exceeded during those two years.

EMD studies have shown that smelter emissions have had an adverse effect on many aspects of the Flin Flon environment.

15. BIBLIOGRAPHY

Caber, J. 1964 Limnological Changes In Schist Lake As A Result Of Mine Tailing Drainage - Manitoba Department of Mines and Natural Resources, Fisheries Branch.

Federal-Provincial Working Group on drinking Water. 1978. Guidelines For Canadian Drinking Water Quality 1978. Published by authority of the Minister of National Health and Welfare.

Franzin, W. and G. McFarlane, and A. Lutz. 1979. Atmospheric Fallout in the Vicinity of a Base Metal Smelter at Flin Flon, Manitoba. American Chemical Society Journal, Dec. 1979.

Hogan and D. Wotton. 1980. A Preliminary Report on The Effects of Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. Submission to the MCEC.

Hughes, M. 1975. Pollution Survey of Schist Lake, 1975 EMD

Impingement Program, 1983. Ambient Air Sulfur Dioxide Levels in the Flin Flon, Manitoba Area. Air Standards and Studies, EMD

Kucera, E. 1980. Emissions Distribution Reflected In Wild Rodent Tissues. Submission to MCEC.

Kucera, E. 1983. Monitoring Smelter Emissions Using Small Mammals as Indicators. Terrestrial Standards and Studies Report.

McEachern, D. and S. F. Phillips. 1983. Monitoring for Mercury and Lead in Blueberry Plants (Vaccinium myrtilloides) of the Flin Flon Area, 1980 and 1981. Terrestrial Standards and Studies Report.

Phillips, S. F., D. L. Wotton, D. B. McEachern and D. C. Jones. Snow Chemistry in the Flin Flon Area of Manitoba 1981-1983 Terrestrial Standards and studies. Environmental Management Division.

Sergy, G. and B. Fallis. 1978. A Study of Water Pollution in the Vicinity of Flin Flon, Manitoba Part B: Effects on Receiving Waters Fisher and Environemnt Canada Environmental Protection Service.

Shewchuk, S. 1982. A Snowpack Chemistry Study of Small Lakes in Northern Saskatchewan. Sask. Research Council Technical Report # 137.

Sparling, A.B. and L. A. Sunde. 1960. Pollution Report Schist Lake - Lke Athapapuskow. Prepared for Manitoba Provincial Sanitary Control Commission.

Van Loon, J.C., and R. J. Beamish, 1977. Heavy-metal Contamination by Atmospheric Fallout of Several Flin Flon Area Lakes and the Relationship to Fish Populations. J. Fish. Res. Board Can. 38: 899-906.

Walmsley, D. 1982. Compilation of Ambient Airborne Heavy Metal In Suspended Particulate Data for the years 1976, 1977, 1979, 1980 from the Provincial Network. Air Standards and Studies.

Williamson, D.A.. 1980. Environmental Assessment Concerning Hudson Bay Mining and Smelting Company Limited Flin Flon Complex Liquid Effluent Discharges. Water Standards and Studies, EMD

Wilson, D. 1984 A Background Study of Trout (Embury) and Cliff Lake. EMD

Wotton, D. 1979 A Survey of Mercury and Lead in Vaccinium mytilloides of the Flin Flon Area. Terrestrial Standards and Studies.

Wotton, D. and D. McEachern and D. Jones. 1983 A Study of Forest Vegetation in the Flin Flon Area for Atmospheric Emission Effects From the HBM&S Smelter. Terrestrial Standards and Studies.

16. ACKNOWLEDGEMENTS

The preparator of General Environment of Flin Flon would like to acknowledge the assistance of the following members of the Environmental Management Division Staff:

Dave Wotton, Dale McEachern, Floyd Phillips, Dale Jones (snow studies and vegetation), Dr. Emil Kucera (effects on small mammals), Adrian Jackson, Barry Cowan, Art Schulz and Kevin Reeve (air pollution control), Dave Bezak (air standards and studies), Dennis Brown, Don Wilson (Cliff and Trout lakes), Norma Godavari, Pat Collins, (Resource Centre).

Don Rocan, Richard Rentz, Bill Franz, Kelly Kjartensen (drinking water), Irene Casey (locating files), Dwight Williamson, William Grieve, Ken Hawkins, Max Morelli, Clem Moche and Lary Strachan.

In addition, advice was also obtained from:

Bob Stewart (Clean Environment Commission).
Dr. Margarett Fast (Department of Health),
Dr. Jack Klavercamp (Freshwater Institute),
Dr. Laila Sekla (Cadham Provincial Laboratory),
George Balacko (Department of Health), and
John Elias (Workplace Safety and Health Division).

Table 2-1

TEMPERATURE AND PRECIPITATION DATA

MANITOBA/MANITOBA

	JAN JAN	FEB FÉV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNEE	CODE CODE	
FLIN FLON A															
54° 41 N 101° 41'W 304 m															
Daily Maximum Temperature	-18 8	-12 3	-4 8	5 8	14 3	19 9	23 0	21 3	13 7	6 9	-4 7	-14 2	4 2	8	Température Maximale Quotidienne
Daily Minimum Temperature	-28 5	-24 5	-18 8	-6 4	2 3	8 9	12 4	11 0	5 1	-0 5	-11 6	-22 7	-6 1	8	Température Minimale Quotidienne
Daily Temperature	**-23.6**	**-18.4**	**-11.9**	**-0.2**	**8.3**	**14.4**	**17.8**	**16.1**	**9.4**	**3.2**	**-8.2**	**-18.5**	**-1.0**	**8**	**Température Quotidienne**
Standard Deviation, Daily Temperature	2 8	3 7	2 8	2 7	2 7	1 4	1 4	1 9	1 7	1 8	1 9	4 0	0 9	5	Ecart Type de la Température Quotidienne
Extreme Maximum Temperature	6 7	6 7	12 8	27 0	29 0	32 8	33 0	33 9	27 5	23 5	17 5	8 3	33 9		Température Maximale Extrême
Years of Record	12	12	12	12	12	12	12	12	11	12	12	12			Années de Relèves
Extreme Minimum Temperature	-44 4	-45 6	-40 6	-31 0	-12 8	-1 7	4 4	1 7	-6 7	-13 9	-33 5	-43 3	-45 6		Température Minimale Extrême
Years of Record	12	12	12	12	12	12	12	12	11	12	12	13			Années de Relèves
Rainfall	0 0	0 0	0 0	5 3	32 5	60 4	64 2	67 4	56 4	19 6	0 9	0 0	306 7	8	Chutes de Pluie
Snowfall	21 0	18 3	21 5	16 6	4 0	0 0	0 0	0 0	1 2	9 0	26 3	23 8	141 7	8	Chutes de Neige
Total Precipitation	**19.2**	**17.2**	**20.7**	**22.7**	**36.8**	**60.4**	**64.2**	**67.4**	**58.6**	**30.7**	**25.6**	**22.4**	**445.9**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	11 5	6 7	11 1	20 3	28 3	48 6	38 7	42 7	33 7	19 6	13 6	13 0	29 0	5	Ecart Type des Précipitations Totales
Greatest Rainfall in 24 hours	T	T	0 0	25 4	36 1	53 8	54 4	51 6	42 9	24 9	9 1	1 3	54 4		Chute de Pluie Record en 24 heures
Years of Record	12	12	12	11	12	12	12	12	11	12	12	13			Années de Relèves
Greatest Snowfall in 24 hours	13 0	10 8	18 3	39 4	18 0	0 0	0 0	0 0	11 7	7 1	25 4	10 4	39 4		Chute de Neige Record en 24 heures
Years of Record	12	12	12	12	12	12	12	12	11	12	11	12			Années de Relèves
Greatest Precipitation in 24 hours	13 2	10 8	15 8	39 4	36 1	53 8	54 4	51 6	42 9	24 9	16 4	10 0	54 4		Précipitation Record en 24 heures
Years of Record	12	12	12	11	12	12	12	12	11	12	11	12			Années de Relèves
Days with Rain	0	0	0	2	8	11	12	12	12	6	1	0	64	8	Jours de Pluie
Days with Snow	10	8	9	5	2	0	0	0	0	3	11	13	61	8	Jours de Neige
Days with Precipitation	10	8	8	6	9	11	12	12	12	9	9	10	116	8	Jours de Précipitation
FLIN FLON CFB															
54° 41'N 101° 58'W 305 m															
Daily Maximum Temperature	-18 0	-11 8	-4 4	6 1	14 9	20 9	23 8	21 7	14 2	7 1	-4 3	-13 8	4 7	8	Température Maximale Quotidienne
Daily Minimum Temperature	-27 6	-23 4	-17 5	-5 8	2 3	8 6	11 9	10 2	4 7	-0 8	-12 1	-22 1	-6 0	8	Température Minimale Quotidienne
Daily Temperature	**-22.8**	**-17.6**	**-11.0**	**0.2**	**8.7**	**14.8**	**17.8**	**16.0**	**9.4**	**3.1**	**-8.2**	**-17.9**	**-0.6**	**8**	**Température Quotidienne**
Standard Deviation, Daily Temperature	3 1	3 7	2 4	2 7	1 4	1 5	1 2	1 4	2 6	3 0	2 8	4 0	0 3	5	Écart Type de la Température Quotidienne
Extreme Maximum Temperature	4 4	10 0	13 9	24 4	27 8	32 8	33 3	35 0	31 7	24 4	9 4	8 3	35 0		Température Maximale Extrême
Years of Record	11	11	12	11	10	11	11	11	11	10	12	11			Années de Relèves
Extreme Minimum Temperature	-44 4	-42 8	-42 2	-27 2	-15 0	-2 8	2 8	1 1	-8 9	-17 2	-33 3	-46 7	-46 7		Température Minimale Extrême
Years of Record	10	11	11	11	11	11	10	10	10	11	11	11			Années de Relèves
Rainfall	0 0	0 0	0 0	10 6	40 0	64 1	68 5	54 0	65 7	27 1	5 5	0 2	335 7	8	Chutes de Pluie
Snowfall	20 0	17 0	23 5	13 7	2 8	0 1	0 0	0 0	0 7	10 4	28 6	25 5	142 3	8	Chutes de Neige
Total Precipitation	**20.0**	**17.0**	**23.5**	**23.8**	**43.8**	**64.2**	**68.5**	**54.0**	**67.9**	**38.7**	**30.3**	**25.7**	**477.4**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	8 9	12 3	6 1	19 7	16 2	32 1	34 8	21 9	39 8	16 2	19 4	15 0	74 0	5	Ecart Type des Précipitations Totales
Greatest Rainfall in 24 hours	0 0	0 0	T	14 0	15 7	36 8	34 5	30 5	69 6	24 9	6 4	T	69 6		Chute de Pluie Record en 24 heures
Years of Record	11	11	11	9	6	9	12	11	10	11	13	13			Années de Relèves
Greatest Snowfall in 24 hours	14 0	12 7	20 3	25 4	27 9	1 3	0 0	0 0	0 8	17 8	26 7	23 4	27 9		Chute de Neige Record en 24 heures
Years of Record	10	10	10	8	7	12	12	12	10	11	13	13			Années de Relèves
Greatest Precipitation in 24 hours	14 0	12 7	20 3	25 4	27 9	36 8	34 5	30 5	69 6	24 9	26 7	23 4	69 6		Précipitation Record en 24 heures
Years of Record	10	10	10	8	6	9	12	11	11	12	13	12			Années de Relèves
Days with Rain	0	0	0	3	8	12	11	11	12	7	0	0	64	8	Jours de Pluie
Days with Snow	8	6	8	3	1	0	0	0	0	3	7	9	43	8	Jours de Neige
Days with Precipitation	8	6	6	5	9	12	11	11	12	9	8	9	106	8	Jours de Précipitation

Source: Atmospheric Environment Service, Environment Canada

Table 2-2

WIND SPEED AND PERCENTAGE FREQUENCY

FLIN FLON A MAN.

PERIOD 1968-80 PERIODE

Lat. 54°41'N Long. 101°41'W

Elevation 304 m Altitude

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
PERCENTAGE FREQUENCY FREQUENCE EN %														
N	13.4	16.5	13.6	8.7	9.2	9.5	10.5	10.7	12.0	13.3	16.8	14.1	12.4	N
NE	12.0	16.5	21.3	24.7	27.3	21.7	14.1	12.8	19.0	10.9	10.3	17.8	17.4	NE
E	2.9	3.4	5.1	4.2	5.5	5.6	3.8	4.7	7.2	6.2	5.6	5.8	5.0	E
SE	6.2	9.6	13.5	20.6	19.0	17.5	12.3	14.9	14.6	13.9	12.0	11.9	13.8	SE
S	12.0	13.2	15.4	16.1	14.9	14.3	12.3	13.1	7.7	11.4	8.1	11.8	12.5	S
SW	6.6	7.2	7.7	7.7	6.4	8.7	12.2	11.8	11.6	12.9	13.8	6.0	9.4	SW
W	11.0	6.0	3.7	3.4	4.0	5.6	9.6	8.7	8.6	9.2	9.5	8.0	7.3	W
NW	26.8	18.8	12.7	9.9	10.7	13.2	22.2	19.5	16.5	20.2	20.8	18.7	17.5	NW
Calm	9.1	8.8	7.0	4.7	3.0	3.9	3.0	3.8	2.8	2.0	3.1	5.9	4.7	Calme
MEAN WIND SPEED IN KILOMETRES PER HOUR VITESSE MOYENNE DES VENTS EN KILOMETRES PAR HEURE														
N	10.9	10.6	11.4	11.3	13.4	13.2	12.2	11.6	12.0	14.6	13.0	9.8	12.0	N
NE	9.5	8.8	10.5	12.4	12.7	13.7	11.8	11.4	14.8	15.2	11.7	10.5	11.9	NE
E	6.5	7.3	9.7	8.5	9.3	8.8	7.6	6.9	9.4	8.2	7.3	6.2	8.0	E
SE	9.1	10.8	10.5	11.9	12.2	11.2	11.1	11.8	11.6	11.9	12.1	9.9	11.2	SE
S	6.8	7.5	8.1	7.6	8.5	8.6	9.2	9.1	9.8	11.1	9.8	7.3	8.6	S
SW	9.4	10.7	10.5	11.9	13.6	13.5	13.1	12.8	13.5	14.0	12.0	9.1	12.0	SW
W	9.4	10.1	9.9	12.0	11.7	12.6	12.8	11.4	11.6	10.6	10.2	8.2	10.9	W
NW	13.7	13.1	14.6	16.3	15.9	15.2	15.2	14.8	14.9	15.6	15.1	13.2	14.8	NW
All Directions / Toutes directions	9.5	9.3	10.0	11.0	11.8	11.8	11.9	11.4	12.4	13.0	11.8	9.3	11.1	
Maximum Hourly Speed / Vitesse horaire maximale	40 NW	35 SVL	35 SVL	42 NE	39 SVL	45 NE	48 SW	42 SW	40 NW	47 SVL	40 N	35 NE	48 SW	

Height of anemometer 10.1 m hauteur de l'anemometre

STATION INFORMATION

Surrounding countryside is very rocky and rolling, covered with trees and numerous lakes. The anemometer is located near the airstrip and the best possible exposure has been obtained.

DONNEES RELATIVES A LA STATION

La region environnante se compose d'un sol trs rocheux et ondule, couvert d'arbres et de nombreux lacs. L'anemomtre se trouve prs de la piste d'envol ou il est expose de la meilleure façon possible.

FLIN FLON CFB MAN.

PERIOD 1963-80 PERIODE

Lat. 54°41'N Long. 101°58'W

Elevation 305 m Altitude

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
PERCENTAGE FREQUENCY FREQUENCE EN %														
N	15.8	16.7	14.1	12.1	13.9	9.5	12.5	13.8	12.5	10.9	11.3	8.6	12.7	N
NE	10.8	8.0	15.0	14.1	15.1	18.7	10.5	13.2	11.4	11.3	14.7	12.1	12.9	NE
E	8.7	7.1	10.6	13.4	13.6	11.3	11.2	10.0	11.1	7.5	7.9	13.7	10.5	E
SE	9.1	11.2	14.7	20.1	18.7	16.2	13.7	13.1	14.6	14.7	12.2	12.4	14.2	SE
S	7.5	10.1	6.4	10.5	7.5	7.2	8.2	9.8	8.9	10.9	9.9	8.2	8.8	S
SW	9.2	14.5	12.8	10.7	10.9	13.1	12.6	13.8	12.4	13.1	11.0	13.9	12.3	SW
W	12.4	12.1	10.8	6.2	6.7	10.0	13.6	10.4	11.4	11.9	10.1	13.9	10.8	W
NW	25.1	19.3	14.9	12.4	13.2	13.4	17.1	15.1	17.0	18.8	21.1	15.8	16.9	NW
Calm	1.4	1.0	0.7	0.5	0.4	0.6	0.6	0.8	0.7	0.9	1.8	1.4	0.9	Calme
MEAN WIND SPEED IN KILOMETRES PER HOUR VITESSE MOYENNE DES VENTS EN KILOMETRES PAR HEURE														
N	9.2	11.5	11.7	13.1	14.9	12.3	11.8	10.0	11.1	11.6	10.8	10.1	11.5	N
NE	9.8	11.1	11.7	13.7	14.5	14.1	11.7	11.8	12.6	12.1	11.9	9.6	12.1	NE
E	8.4	8.8	9.2	9.7	10.9	11.4	9.4	8.8	10.6	9.5	8.9	8.3	9.5	E
SE	9.9	10.2	12.7	12.2	13.3	13.3	12.6	13.2	12.2	12.1	10.7	9.8	11.9	SE
S	7.6	8.0	7.7	9.2	9.5	9.3	9.1	9.4	9.6	8.6	9.0	6.6	8.6	S
SW	9.5	10.6	11.3	12.2	11.9	12.7	11.2	11.8	11.9	10.5	10.3	8.8	11.1	SW
W	9.0	8.0	9.6	9.8	11.0	10.6	10.6	8.8	10.6	9.4	7.8	7.7	9.4	W
NW	12.9	14.0	13.9	15.4	16.4	15.6	14.0	13.9	14.6	14.0	13.4	12.9	14.3	NW
All Directions / Toutes directions	10.0	10.6	11.3	12.1	13.2	12.7	11.5	11.1	11.8	11.2	10.6	9.3	11.3	
Maximum Hourly Speed / Vitesse horaire maximale	39 NW	42 NE	43 NE	39 SVL	42 NE	39 NW	35 SVL	39 W	37 NW	43 N	43 NW	42 NW	43 SVL	

Height of anemometer 10.1 m hauteur de l'anemometre

STATION INFORMATION

Located 10 km west of the town of Flin Flon. Surrounding country is rocky, rolling and covered with evergreen trees.

DONNEES RELATIVES A LA STATION

Se trouve à 10 km à l'ouest de la ville de Flin Flon. La region environnante se compose d'un sol rocheux, ondule et recouvert de conifres.

Source: Atmospheric Environment Service, Environment Canada

TABLE 4-1

EMD AND HBM&S MONITORING STATIONS

Ambient Sulfur Dioxide Monitoring

Station	Distance and Direction from Stack
City Hall	0.7 km SE
Channing	3.1 km ESE
Creighton	3.5 km SSW
Phantom Lake	3.2 km S
Hudson Bay Airport Terminal	4.5 km SSE

High-Volume Sampling (1977)

Station	Distance and Direction from Stack
City Hall	0.9 km SE
Sewage Treament Plant	2.14 km SE
Manitoba Hydro	2.44 km SE

Snow Studies

Station No.	Distance and Direction from Stack
1	5.1 km ESE
2	8.9 km ESE
3	15.5 km ESE
4	38.1 km ESE
5	5.8 km SSE
6	14.6 km SSE
7	35.7 km SSE

Blueberry Studies

Station No.	Distance and Direction from Stack
1	5.1 km ESE
2	8.9 km ESE
3	15.5 km ESE
4	38.9 km ESE
5	5.8 km SSE
6	14.6 km SSE
7	2.5 km SSE
8	4.6 km NNE
9	3.7 km ESE
10	3.2 km ENE
11	2.0 km NNE

Site 4 (Cranberry Portage) is considered to be background

Reproduced from Original

TABLE 5-1

MASS BALANCE CALCULATIONS FOR SULFUR DIOXIDE (1950 - 1985)

in Short Tons/Day

Total Emissions

	Daily Avg. Sulfur	Daily Avg. Sulfur Dioxide
1950-54	432	864
1955-59	436	872
1960-64	424	848
1965-69	393	786
1970-74	405	810
1975-79	399	798
Avg.	415	830
1975	403	806
1976	362	724
1977	405	810
1978	413	826
1979	411	822
1981	377	755
1982	377	755
1983	398	796
1984	391	783
1985	412	823

Source: HBM&S supplied data, on file at MEMD

Reproduced from Original

TABLE 5-2: 1981 EMD DATA

PARTICULATE DATA H.B.M.&S.

TEST	#1	#2	#3	AVERAGE
Date	Sept. 21/81	Sept. 22/81	Sept. 23/81	
Sampling Time (minutes)	180	180	180	
Sample Volume (scf)	122.006	129.755	124.186	125.316
Average Stack Temperature (^{o}R)	809	794	790	798
Average Stack Velocity (ft/sec)	53.65	56.02	54.64	54.77
Stack Flow Rate (scf/hr)	28,227,360	30,197,460	29,537,280	29,320,700
% Moisture	3.9	3.3	2.9	3.4
Emission Rate (lbs/hr)	4287	3326	3688	3757
(tons/day)	51.4	39.9	44.3	45.2
Particulate Concentration (grains/scf)	1.063	0.771	0.874	0.903
(grams/scm)	2.437	1.768	2.000	2.068

Source: MEMD files

TABLE 5-3

SULPHUR DIOXIDE EMISSIONS H.B.M. & S.

TEST	#1	#2	#3	AVERAGE
Date	Sept. 24/81	Sept. 24/81	Sept. 24/81	
Total Gas Volume ($ft.^3$)	15.25	20.01	21.16	18.81
Gas Volume (scf)	15.54	20.31	21.32	19.02
Average Stack Temperature (^{o}R)	750	739	738	746
Average Stack Velocity (ft/sec)	58.44	58.33	54.24	57.00
Stack Volumetric Flow (scf/hr)	35,040,120	35,968,020	33,491,340	34,833,160
SO_2 Concentration (grams/scm)	38.22	21.06	27.35	28.88
(grains/scf)	16.70	9.20	11.95	12.62
SO_2 Emission Rate (tons/day)	1003	567	686	752

Source: MEMD Files

Reproduced from Original

TABLE 5-4

COMPLIANCE TEST - 1981

Data Collected by HBM&S

(i) Particulates

	#1 Sept. 21	#2 Sept. 22	#3 Sept. 23	Average
Sampling Time (Min)	180	180	180	
Tot Gas Vol (ref) (ft^3)	117.95	129.91	124.34	124.07
Avg. Temp. Stack (F)	353	334	330	339.0
Avg. Stack Velocity (ft/sec)	54.52	56.08	54.36	54.99
Avg. Flow Rate (SCF/hr)	28 500 000	30 300 000	29 400 000	29 400 000
Moisture Content (%)	4	3	3	3.33
lb/hr	4485	3328	3674	3828
Tons/day	53.82	39.94	44.09	45.94

(ii) Particulate Size

5u (Probe and Cyclone)	85.7%	86.5%	79.5%	
0.3-5u (Filter)	14.3	13.5	20.5	

(iii) Particulate Composition

Al_2O_3	3.38%*	3.47%	3.79%	3.55%
As	0.51	0.37	0.35	0.58
Cd	0.4	0.56	0.34	0.43
CaO	2.19	2.49	2.34	2.34
Cr	Trace**	Trace	Trace	---
Co	Trace	Trace	Trace	---
Cu	1.53	1.45	1.22	1.40
Fe	9.74	8.18	8.97	8.96
Pb	3.98	3.93	3.82	3.91
MgO	0.70	0.73	0.53	0.59
Mn	0.08	0.06	0.07	0.07
Ni	0.06	0.06	0.05	0.05
Se	0.08	0.08	0.07	0.08
Zn	42.04	41.33	43.33	42.24
SiO_2	N/A	N/A	N/A	

* Cyclone and filter results combined

** Trace concentrations were those less than 0.01%

Reproduced from Original

TABLE 5-5

SULFURE DIOXIDE

Data Collected by HBM&S 1981

	#1 10:02-10:22 a.m.	#2 1:40-2:08 p.m.	#3 3:25-3:53 p.m.	Average
Sampling Time (min.)	20	28	28	---
Total Gas Vol. (ft^3)	15.25	20.01	21.16	---
Avg. Temp. Stack (F)	300	279	273	295
Avg. Stack Velocity (ft/sec)	58.44	58.33	54.24	57.0
Avg. Flow Rate (SCF/hr)	33 610 000	35 600 000	32 500 000	33 900 000
SO_2 Concentration (g/m^3)	38.46	21.19	27.41	29.02
Emission Rate (tons/day)	967	564	667	733

Reproduced from Original

TABLE 5-6

1982 COMPLIANCE TESTS

Data Collected By HBM&S

Test Results

(i) Particulate Summary

Test Number	1	2	3	Average
Date	Sept. 20/82	Sept. 21/82	Sept. 22/82	
Test Time (p.m.)	10:48-2:41	9:40-1:40	10:5-2:40	
Test Duration (min.)	180	180	180	180
Isokinetics (%)	100.27	101.39	98.60	100.09
Total Sample Volume (SCF)	136.16	139.60	133.25	136.34
Flow Rate (SCFM)	507 309	510 089	498 058	505 152
Temperature (F)	342	329	374	348
Moisture (%)	3.0	2.0	3.0	2.7
Molecular Weight Dry (lb/lbmole)	28.70	28.70	28.70	28.70
Grains/SCF	0.199	0.338	0.221	0.253
Grams/NCM	0.45	0.77	0.56	0.59
Tons/day	10.69	18.16	11.64	13.50
Tonnes/day	9.70	16.48	10.56	12.25
Assay (%) Al_2O_2	0.3	0.10	0.3	0.23
As	2.5	1.89	2.6	2.33
Cd	0.93	0.86	1.26	1.02
CaO	0.16	0.25	0.17	0.17
Cr	0.15	0.11	0.12	0.13
Co	0.004	0.004	0.005	0.004
Cu	2.7	1.6	2.7	2.33
Fe	3.0	2.1	3.0	2.7
Pb	6.4	7.1	9.0	7.5
MgO	0.14	0.12	0.17	0.14
Mn	0.024	0.018	0.020	0.021
Ni	0.097	0.065	0.079	0.081
SiO_2	1.2	----	----	1.2
Zn	21.4	24.4	19.2	21.7

(ii) Sulfur Dioxide Summary

Test Number	1	2	3	Average
Date	Sept. 23/82	Sept. 23/82	Sept. 23/82	
Test Time (p.m.)	10:05-10:35	11:27-11:57	2:09-2:39	
Test Duration (min.)	30	30	30	30
Total Sample Volume (SCF)	22.73	22.39	22.52	22.55
Flow Rate (SCFM)	507 644	534 538	524 442	521 241
Temperature (F)	298	296	345	313
SO_2 Concentration (grams/CM)	14.90	25.22	26.23	22.12
SO_2 Mass Emission (tpd)	339.72	605.78	614.31	519.94

Reproduced from Original

TABLE 5-7

SUMMARY OF PARTICULATE CONCENTRATIONS AND EMISSION RATES

1983 EMD DATA

TEST NUMBER	1	2	3	AVERAGE
Sample Volume, dscm	3.9347	4.0607	3.8590	3.9515
Particulate Content, mg	803.9	1333.4	1052.1	1063.1
Particulate Concentration g/dscm	0.204	0.328	0.273	0.268
Stack Gas Volumetric Flowrate dscm/hr	886,255	945,932	915,815	916,001
Particulate Emission Rate kg/hr	180.8	310.3	250.0	247.0
*Particulate Emission Rate Tons (2,000 lbs)/Day (24 hrs)	4.8	8.2	6.6	6.5

* Particulate emission rate is calculated on a dry basis at standard conditions. That is 25° Celsius and 760 mm of mercury at the point of emission.

Source: Particulate Emissions From Main Stack, HBM&S Flin Flon 1983, EMD

Reproduced from Original

TABLE 5-8

1984 PARTICULATE DATA COLLECTED BY HBM&S

TEST NUMBER	1	2	3	AVERAGE
Sample Volume (scfm)	149.12	144.87	143.92	145.97
Particulate Content (GR.)	2.22	1.48	2.19	1.96
Particulate Concentration (GR/CF)	0.15164	0.15190	0.10480	0.13611
Stack Gas Volumetric Flow Rate (scfm)	626886.13	601529.75	549128.5	607514.79
Particulate Emission Rate Tons/Day (24 Hrs.)	14.89	14.64	9.90	13.15

Source: Particulate and Sulfur Dioxide Emissions From Main Stack, HBM&S 1984, HBM&S

Summary of Particulate Concentration and Emission Rates

Reproduced from Original

TABLE 5-9

1984

PARTICULATE TEST ASSAYS %

TEST #	ONE	TWO	THREE	AVERAGE
Al_2O_3	0.99	1.49	0.45	0.98
Cd	0.86	0.84	0.84	0.85
CaO	0.98	1.19	1.19	1.12
Cr	0.30	0.23	0.29	0.27
Co	0.006	0.005	0.005	0.005
Cu	1.97	2.72	2.04	2.24
Zn	27.12	25.51	23.89	25.54
Fe	6.70	5.20	4.99	5.96
Pb	3.40	2.98	4.14	3.51
MgO	0.23	0.29	0.24	0.25
Ni	0.20	0.13	0.16	0.16
Mn	0.04	0.03	0.04	0.037
As	0.31	0.25	0.20	0.25

Source: Particulate and Sulfur Dioxide Emissions From Main Stack, Hudson Bay Mining and Smelting, Flin Flon, 1984, HBM&S

Reproduced from Original

TABLE 5-10

1984 SULFUR DIOXIDE

SUMMARY OF SO_2 SAMPLING VARIABLES

TEST NUMBER	ONE	TWO	THREE	AVERAGE
Date	Sept. 27	Sept. 17	Sept. 27	---
Test Time	9:27 a.m. 9:57 a.m.	10:15 a.m. 10:45 a.m.	11:54 a.m. 12:24 a.m.	
Test Duration (min.)	30	30	30	30
Total Sample Volume (scf)	22.73	22.70	22.63	22.69
Flow Rate (scfm)	647143.25	646511.50	632823.50	642159.42
Temperature (f)	275.0	267.37	281.27	274.55
SO_2 Concentration (G/CM)	18.12	17.87	17.59	17.86
SO_2 Mass Emission (TPD)	526.63	519.01	499.96	515.20

Reproduced from Original

TABLE 5-11

SUMMARY OF MONTHLY EMISSIONS OF SO_2 AND TOTAL PARTICULATE MATTER

HUDSON BAY MINING AND SMELTING COMPANY LTD., FLIN FLON.

MASS BALANCE CALCULATIONS

Month	Short Tons/Day SO_2	Total Particulate Matter
1981		
April	733	48.1
May	730	48.1
June	770	38.7
July	734	38.7
August	790	38.7
September	751	45.9
October	514	45.9
November	880	45.9
December	785	40.9
Average	755	43.4
1982		
January	734	29.4
February	731	29.4
March	781	19.0
April	820	16.3
May	817	14.4
June	762	14.4
July	xx	xx
August	418	N/A
September	816	15.1
October	758	13.5
November	860	13.5
December	816	13.5
Average	755	16.1
1983		
January	790	13.5
February	813	13.5
March	813	13.0
April	832	12.2
May	825	12.4
June	766	12.4
July	712	7.5
August	808	7.5
September	757	N/A
October	840	N/A
November	--	--
December	--	--
Average	796	11.5

.../Cont'd.

Table 5-11 (Cont'd.)

Month	Short Tons/Day SO2	Total Particulate Matter
1984		
January	790	8.9
February	864	9.1
March	845	8.0
April	954	13.5
May	575	12.2
June	752	17.5
July	798	12.9
August	757	13.3
September	812	13.3
October	822	15.3
November	939	12.5
December	573	12.5
Average	783	12.4
1985		
January	800	12.6
February	805	10.8
March	831	17.0
April	858	15.6
May	856	12.3
June	806	10.0
Average	783	12.4

XX Plant Shutdown

N/A Not Available

Reproduced from Original

TABLE 6-1

DATA SUMMARY FOR AMBIENT AIR MONITORING OF SULPHUR DIOXIDE IN FLIN FLON AREA

	CREIGHTON - HBM&S 3.5 km SSW			HBAT - HBM&S 4.5 km SSE			PHANTOM LAKE-EMD* 3.2 km S			CHANNING - EMD* 3.1 km ESE			FLIN FLON - EMD 0.71 km SE		
	Above MDL 0.17	Above MAL 0.34	Max. Rec.	Above MDL 0.17	Above MAL 0.34	Max. Rec.	Above MDL 0.17	Above MAL 0.34	Max. Rec.	Above MDL 0.17	Above MAL 0.34	Max. Rec.	Above MDL 0.17	Above MAL 0.34	Max. Rec.
1973	-	-	-	-	-	-	-	-	-	119	45	.75	289	190	1.16
1974	-	-	-	-	-	-	-	-	-	250	128	1.00	358	170	1.03
1975	-	-	-	-	-	-	-	-	-	92	0	.18	67	8	.57
1976	14	1	.49	36	9	.65	14	1	.35	10	0	.31	108	10	.51
1977	29	10	.61	40	8	1.02	9	0	.27	24	6	.53	65	11	.80
1978	46	8	.77	39	10	.54	33	5	.56	34	9	1.00	94	19	.81
1979	47	14	.64	43	9	.78	68	22	.92	37	14	.82	58	21	1.22
1980	40	13	.97	53	13	1.14	21	2	.65	49	6	.64	67	17	.81
1981	31	11	.92	58	19	1.18	54	21	1.06	61	30	1.25	61	20	1.11
1982	43	20	.79	17	0	.33	12	7	.56	38	8	.82	71	9	1.00
1983	35	14	.68	21	6	.64	40	11	1.00	60	19	1.10	89	19	.79
1984	20	9	.80	9	5	.59	25	3	.58						

SOURCE: Prepared from raw data for this report

* Data adjusted to 100% effective monitoring

Reproduced from Original

TABLE 6-2

TEN YEAR PRODUCTION RECORD

1974 - 1984

Ore Milled and Ore Grades

	Milled (tons)	Copper (%)	Zinc (%)	Gold (oz/ton)	Silver (oz/ton)
1974	1 574 948	2.9	3.9	0.05	0.70
1975	1 470 158	2.8	4.2	0.03	0.60
1976	1 562 655	2.7	2.9	0.035	0.55
1977	1 821 598	2.8	2.7	0.036	0.53
1978	1 850 781	2.8	2.7	0.04	0.55
1979	1 874 835	2.7	2.7	0.04	0.55
1980	1 875 369	2.7	2.8	0.04	0.54
1981	1 935 015	2.9	2.2	0.034	0.53
1982	1 798 000	2.1	2.8	0.043	0.53
1983	2 114 992	2.2	2.9	0.042	0.48
1984	2 100 000	2.5	2.7	0.044	0.55

Production

	Copper (tons)	Zinc (tons)	Cadmium (lbs)	Gold (oz)	Silver (oz)
1974	54 778	77 996	298 736	51 824	1 096 631
1975	55 446	55 464	139 698	55 404	1 231 086
1976	61 275	60 430	282 995	55 734	1 220 853
1977	67 582	75 910	219 373	74 393	1 322 039
1978	68 391	73 552	257 562	71 769	1 327 601
1979	67 463	73 714	194 478	64 645	1 206 729
1980	72 898	76 516	194 290	76 430	1 333 375
1981	74 135	74 597	184 804	65 214	1 257 289
1982	60 332	61 432	87 900	70 000	1 360 000
1983	72 962	81 740	174 900	74 478	1 294 713
1984	71 087	87 454	287 400	70 067	1 349 271

Source: "This is Hudson Bay Mining...", HBM&S Public Relations Dept. 1984

Reproduced from Original

TABLE 7-1

Flin Flon; Site: F-1, F-2

Time Sequence: Summer of 1977

Geometric Means in ug/m^3

	TSP	Cu	Pb	Fe	Cd	As
June	44.23	0.320	0.210	2.56	0.010	0.010
July	38.89	0.210	0.160	1.82	0.010	--
August	49.17	0.420	0.340	1.96	0.010	--
Seasonal	44.16	0.310	0.230	2.08	0.010	--

TABLE 7-2

Flin Flon: Site: F-3, F-4

	TSP	Cu	Pb	Fe	Cd	As
June	30.16	0.110	0.120	1.010	0.010	0.010
July	24.47	0.510	0.060	0.530	0.010	--
August	28.27	0.320	0.130	0.970	0.010	--
Seasonal	28.37	0.120	0.100	0.900	0.010	--

TABLE 7-3

Flin Flon; Site: F-5, F-6

	TSP	Cu	Pb	Fe	Cd	As
June	42.65	0.190	0.170	1.16	0.020	0.020
July	37.60	0.190	0.090	1.25	0.010	--
August	19.77	0.120	0.070	0.730	0.020	--
Seasonal	33.26	0.170	0.110	1.06	0.010	--

TABLE 7-4

Winnipeg; Site: 70101

Time Sequence: Summer of 1977

Geometric Means in ug/m^3

	TSP	Cu	Co	Pb	Fe	Cd	Ni	As	Mn
June	--	--	--	--	--	--	--	--	--
July	88.79	0.110	0.015	0.440	1.19	0.003	0.020	0.002	0.050
August	57.19	0.090	0.015	0.680	0.880	0.003	0.010	0.003	0.050
Seasonal	75.26	0.100	--	0.490	1.06	--	0.010	--	0.050

Source: Compilation of Ambient Ariborne Heavy Metal in Suspended Particulate Walmsley; EMD

Reproduced from Original

Table 8-1

Deposition of Selected Elements in Snow on Lake Surfaces Near Flin Flon for the Period November 8, 1976 to February 2, 1977

direction from smelter	lake[a]	km[2]	mm[c]	wind[d]	pH	mg·m^{-2}												
						Cl	SO_4	Na	K	Mg	Ca	Fe	Mn	Pb	As	Cd	Cu	Zn
N	WHI-W	5.6	38.9	10.3	5.48	16.0	70.0	6.6	0.0	2.7	11.0	14.0	0.3	9.1	1.40	0.90	15.0	412.0
	WHI-E	5.6	49.7	10.3	5.73	30.0	109.0	7.0	0.0	3.5	11.0	25.0	0.4	14.0	1.70	1.40	16.0	586.0
	PRE-S	11.6	47.6	10.3	5.32	29.0	19.0	8.1	0.0	1.4	4.3	25.0	0.2	3.1	0.50	0.30	2.3	104.0
	PRE-N	11.6	43.8	10.3	5.64	18.0	35.0	5.3	0.0	3.9	16.0	14.0	0.2	4.1	0.60	0.40	2.7	142.0
	WEB-A	13.6	62.9	10.3	6.13	38.0	76.0	16.0	2.5	15.0	43.0	16.0	1.1	4.3	0.80	0.40	3.6	132.0
	WEB-B	13.6	56.2	10.3	5.46	34.0	45.0	16.0	0.0	6.2	21.0	13.0	0.2	3.2	0.70	0.30	2.7	77.0
NE	CLI-W	4.0	57.7	9.5	6.17	92.0	150.0	28.0	0.0	13.0	48.0	31.0	1.2	15.0	2.30	1.40	50.0	733.0
	CLI-E	4.0	57.3	9.5	5.22	34.0	115.0	9.2	0.0	5.7	24.0	26.0	0.9	17.0	1.90	1.30	34.0	619.0
	L-SIX	5.2	50.2	9.5	5.37	20.0	40.0	3.0	0.0	1.0	4.5	12.0	0.5	5.9	1.10	0.70	31.0	335.0
	EMB-S	8.0	66.9	9.5	5.90	27.0	67.0	8.0	0.0	5.4	25.0	6.8	1.1	6.0	0.90	0.50	8.3	203.0
	EMB-N	8.0	57.7	9.5	6.33	35.0	115.0	13.0	2.3	22.0	72.0	6.2	0.4	6.1	0.80	0.40	8.0	222.0
E	BIL-WW	6.2	40.6	12.0	7.36	33.0	219.0	13.0	5.3	38.0	135.0	9.5	0.9	10.0	1.30	1.10	23.0	467.0
	BIL-WN	6.2	33.9	12.0	6.60	20.0	115.0	6.5	0.0	17.0	53.0	8.6	0.5	11.0	1.20	0.90	22.0	482.0
	BIL-EW	8.6	34.6	12.0	6.64	21.0	118.0	8.0	1.4	16.0	59.0	9.0	0.4	8.5	0.90	0.60	12.0	360.0
	BIL-EE	8.6	43.0	12.0	6.69	43.0	138.0	14.0	1.7	21.0	70.0	9.2	0.6	11.0	1.20	0.90	15.0	428.0
	WHF-W	14.6	44.1	12.0	6.14	26.0	44.0	8.4	0.0	4.8	30.0	4.8	0.2	5.2	0.70	0.40	7.2	152.0
	WHF-E	14.6	56.9	12.0	6.74	46.0	80.0	22.0	4.6	22.0	79.0	5.0	0.3	4.5	0.70	0.40	5.5	124.0
	THO-W	20.2	50.9	12.0	5.32	20.0	41.0	11.0	0.0	3.6	14.0	5.2	0.2	2.8	0.30	0.20	2.4	63.0
	THO-E	20.2	51.5	12.0	6.30	31.0	41.0	12.0	0.0	13.0	57.0	3.1	0.2	2.0	0.30	0.10	1.7	44.0
SE	NWA-M	6.9	60.9	41.0	6.37	146.0	658.0	33.0	0.0	15.0	81.0	192.0	3.3	81.0	10.00	7.00	113.0	3735.0
	NWA-E	6.9	29.9	41.0	6.36	72.0	263.0	21.0	0.0	5.7	64.0	47.0	1.2	23.0	2.80	2.00	27.0	1039.0
	HOO-A	9.5	46.4	41.0	6.01	28.0	149.0	3.7	0.0	2.3	6.5	25.0	0.9	18.0	2.10	1.70	18.0	696.0
	HOO-B	9.5	76.4	41.0	6.21	46.0	245.0	6.9	0.0	4.6	18.0	78.0	1.5	36.0	4.00	3.10	35.0	1414.0
	BAK-M	19.4	40.5	41.0	7.19	81.0	154.0	19.0	0.0	11.0	71.0	12.0	0.4	6.1	0.90	0.50	5.6	174.0
	BAK-E	19.4	42.7	41.0	7.12	772.0	813.0	178.0	22.0	86.0	513.0	20.0	0.6	9.8	0.90	0.80	8.0	255.0
	ATH-A	38.0	58.3	41.0	4.90	47.0	23.0	19.0	0.0	2.9	8.2	3.5	0.2	1.5	0.30	0.10	0.9	19.0
	ATH-B	38.0	83.6	41.0	6.15	34.0	34.0	13.0	0.0	20.0	54.0	4.5	0.2	3.7	0.60	0.20	2.1	34.0
	SIM-A	54.0	75.9	41.0	5.39	30.0	15.0	4.6	0.0	6.1	18.0	4.1	0.2	1.2	0.30	0.01	1.0	16.0
	SIM-B	54.0	56.2	41.0	6.50	23.0	23.0	11.0	0.0	41.0	21.0	2.9	0.3	1.7	0.30	0.01	0.8	17.0
S	POT-W	4.5	44.8	7.3	6.20	27.0	296.0	9.0	0.0	8.5	33.0	104.0	1.6	28.0	3.60	3.70	36.0	1277.0
	POT-E	4.5	60.1	7.3	6.17	36.0	313.0	1.8	0.0	4.2	22.0	145.0	23.0	34.0	6.10	3.80	63.0	1347.0
	PHA-SW	8.5	53.6	7.3	5.84	32.0	118.0	1.6	0.0	2.7	9.6	40.0	1.8	18.0	2.40	1.70	16.0	825.0
	PHA-SE	8.5	56.5	7.3	8.04	57.0	362.0	36.0	18.0	66.0	203.0	58.0	1.6	25.0	4.00	2.00	21.0	1062.0
	WA-N	12.0	45.3	7.3	6.06	25.0	220.0	1.3	0.0	3.0	16.0	20.0	0.9	17.0	2.30	1.40	16.0	630.0
	WA-S	12.0	47.8	7.3	6.21	38.0	134.0	5.3	0.0	3.3	11.0	21.0	0.8	15.0	2.20	1.30	14.0	564.0
SW	DOU-E	5.0	55.0	4.0	6.68	44.0	66.0	11.0	0.0	9.9	79.0	25.0	0.5	6.8	0.90	0.60	13.0	261.0
	DOU-W	5.0	39.3	4.0	6.09	24.0	55.0	7.9	0.0	3.5	31.0	19.0	0.4	5.9	0.70	0.50	12.0	214.0
	PAT-E	9.5	44.7	4.0	5.45	27.0	27.0	10.0	0.0	4.0	14.0	19.0	0.4	2.6	0.50	0.30	4.9	114.0
	PAT-W	9.5	53.4	4.0	5.84	32.0	21.0	11.0	0.0	5.3	35.0	15.0	0.3	2.5	0.30	0.20	3.3	83.0
	BIR-E	14.0	40.8	4.0	4.95	33.0	8.2	5.7	0.0	4.1	15.0	8.0	0.3	0.7	0.20	0.10	1.0	26.0
	BIR-W	14.0	39.9	4.0	5.45	56.0	8.0	19.0	0.0	6.8	22.0	7.0	0.2	0.8	0.10	0.10	0.7	25.0
	AMI-E	17.5	59.7	4.0	5.00	36.0	12.0	22.0	0.0	3.6	11.0	5.1	0.1	1.0	0.10	0.05	1.0	14.0
	AMI-W	17.5	43.0	4.0	4.82	26.0	0.0	12.0	0.0	3.0	10.0	3.5	0.1	1.2	0.02	0.03	1.0	7.6
W	MER-E	7.0	48.6	1.5	5.24	29.0	19.0	16.0	0.0	2.4	6.8	5.2	0.1	4.1	0.40	0.20	1.8	97.0
	MER-W	7.0	62.1	1.5	5.26	37.0	25.0	19.0	0.0	5.0	20.0	5.3	0.2	2.7	0.40	0.20	2.4	109.0
	TUL-A	71.0	57.7	1.5	4.31	23.0	11.0	9.2	0.0	2.9	10.0	8.4	0.2	1.5	0.10	0.10	1.4	36.0
	TUL-B	71.0	37.2	1.5	4.91	22.0	0.0	10.0	0.0	1.9	3.3	27.0	0.1	0.2	0.10	0.01	0.1	1.8
NW	HAM-N	4.2	57.7	8.4	5.75	46.0	23.0	23.0	0.0	4.6	27.0	74.0	0.8	5.3	2.70	0.40	4.2	151.0
	HAM-S	4.2	49.3	8.4	5.27	39.0	20.0	18.0	0.0	2.0	8.9	25.0	0.4	4.0	0.60	0.40	3.1	181.0
	NES-E	12.5	69.8	8.4	5.08	61.0	26.0	36.0	0.0	3.1	6.1	19.0	0.2	0.9	0.30	0.10	0.5	13.0
	NES-W	12.5	46.6	8.4	5.18	24.0	0.0	11.0	0.0	2.4	5.6	5.5	0.4	1.2	0.20	0.10	0.8	20.0
	TYR-A	21.0	40.3	8.4	4.87	24.0	0.0	11.0	0.0	2.4	7.3	5.7	0.1	0.6	0.10	0.04	0.4	5.1
	TYR-B	21.0	47.0	8.4	4.75	9.4	0.0	3.8	0.0	1.4	4.2	5.0	0.2	3.0	0.04	0.02	0.2	4.2

Source: Atmospheric Fallout in the Vicinity of a Base Metal Smelter at Flin Flon, Manitoba. Franzin, W. et al. 1979

TABLE 8-2

TOTAL MASS OF ELEMENTS MEASURED ON LAKE SURFACES NEAR FLIN FLON ON FEBRUARY 2, 1977, AFTER 85 DAYS OF SNOW ACCUMULATION [a]

Lake	Area, km^2	Element Loads, kg							Metal	kg	
		Fe	Mn	Pb	As	Cd	Cu	Zn		SO_4^{2-}	H^+
Birch	1.66	12	0.36	1.3	0.24	0.13	1.4	42	57	13	0.50
Cliff	2.46	70	2.6	39	5.0	3.3	103	1663	1886	326	0.48
Douglas	1.22	27	0.54	7.7	0.90	0.68	15	290	342	74	0.02
Embury	13.12	85	10	79	11	6.2	105	276	572	1194	0.72
Hamell	2.33	115	1.4	10	3.7	0.8	8.5	387	526	50	0.42
Hook	0.90	46	1.1	24	2.7	2.2	24	950	1050	177	0.05
Meridan	1.23	6.5	0.18	4.2	0.53	0.26	2.6	127	141	27	0.38
Patmore	0.71	12	0.25	1.8	0.29	0.16	2.9	70	87	17	0.09
Phantom	4.78	315	8.7	125	19	4.4	163	5391	6026	1301	0.18
Precipice	1.45	22	0.25	5.2	0.82	0.58	3.6	178	210	39	0.24
Six	0.19	2.3	0.10	1.1	0.21	0.12	5.9	64	74	8[b]	0.21
Thompson	2.20	9.1	0.45	5.3	0.67	0.36	4.5	118	138	90	0.30
Tulabi	12.74	225	2.2	7.6	1.2	0.51	9.6	239	485	148[c]	10.2
Tyrrell	5.34	29	0.77	2.6	0.48	0.16	1.7	25	60	[d]	3.7
Whitefish	1.23	6.0	0.30	6.0	0.84	0.44	7.8	170	191	75	0.02
Whitehead	0.39	7.5	0.15	4.5	0.60	0.45	6.0	195	214	35	0.04

[a] Calculations are based on means of duplicate samples.

[b] One sample only.

[c] One sample only, second sampled below detection limit of 0.02 ppm.

[d] Below detection limit of 0.2 ppm.

SOURCE: Atmospheric Fallout in the Vicinity of A Base Metal Smelter at Flin Flon, Manitoba. Franzin, et al. 1979.

Reproduced from Original

TABLE 8-3

CHEMICAL ANALYSIS OF SNOW FROM THE STUDY PLOTS, FLIN FLON 1979

Plot Number	Distance from stack (km)	pH	mg/l							
			SO4	Zn	Ni	Pb	Cu	Fe	As	Cd
1	5.1	5.67	6.2	28.0	.012	.085	.47	.61	.039	.005
2	8.9	5.91	6.2	43.0	.015	.09	.39	.62	.039	.005
3	15.5	5.84	5.0	7.8	.017	.06	.172	.25	.021	.005
4	38.1	6.15	5.0	.92	.012	.035	.03	.14	.008	.005
5	5.8	6.01	10.0	24.6	.51	.42	.97	.68	.068	.020
6	14.6	5.65	5.0	8.2	.012	.062	.17	.73	.026	.005
7	35.7	5.18	5.0	1.58	.007	.012	.032	.17	.019	.005
8	68.2	5.1	5.0	.28	.015	.012	.010	.095	.001	.005

Source: A Preliminary Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. Hogan and Wotton, 1980.

Reproduced from Original

TABLE 8-4

CHEMICAL ANALYSIS OF SNOW FROM THE STUDY PLOTS, FLIN FLON 1980

Plot Number	Distance from stack (km)	pH	mg/l							
			SO4	Zn	Ni	Pb	Cu	Fe	As	Cd
1	5.1	5.67	15.0	43.0	0.005	0.19	1.82	1.19	0.078	0.005
2	8.9	5.91	5.0	34.0	0.005	0.205	0.425	0.94	0.067	0.005
3	15.5	5.84	5.0	10.6	0.005	0.10	0.305	0.34	0.029	0.005
4	38.1	6.15	5.0*	1.26	0.005	0.05	0.075	1.3	0.020	0.005
5	5.8	6.01	10.0	55.0	0.015	1.0	1.62	1.0	0.126	0.055
6	14.6	5.65	5.0	10.2	0.005	0.125	0.34	0.94	0.042	0.005
7	35.7	5.18	5.0	0.95	0.015	0.01	0.025	0.47	0.023	0.005
8	68.2	--	5.0	0.13	0.005	0.01	0.01	0.02	0.005	0.005

- Less than

Source: A Preliminary Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. Hogan and Wotton, 1980.

Reproduced from Original

TABLE 8-5

ACCUMULATION OF ZINC IN SNOW (mg/m^2) IN THE FLIN FLON AREA FOR THE WINTERS OF 1980/81, 1981/82 AND 1982/83

Site	Distance (KM)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	1450.71	2188.31	2552.13	2658.26	2124.05	2819.18	49.93	0.46	55.66
5	5.8	3083.60	4472.86	5393.67	1322.07	2726.36	2256.66	129.41	0.36	83.50
2	8.9	1343.10	1976.42	2096.88	704.04	1438.71	1863.89	95.07	0.54	54.80
6	14.6	276.51	567.65	559.67	152.63	392.15	209.46	15.03	0.66	11.53
3	15.5	409.22	441.62	686.53	254.62	330.37	215.73	34.24	0.93	13.21
7	35.7	42.40	127.37	97.04	9.71	51.42	71.62	5.25	0.53	10.05
4	38.1	55.39	81.06	84.99	14.36	39.39	38.11	3.31	0.68	4.24

SOURCE: Snow Chemistry in the Flin Flon Area of Manitoba, 1981-1983, EMD

Reproduced from Original

TABLE 8-6

MEAN DEPOSITION OF IRON TO SNOW (mg/m^2), FLIN FLON, MANITOBA

1981 - 1983

Site	Distance (KM)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	23.58	68.14	63.22	60.59	54.96	69.95	4.69	2.14	12.14
5	5.8	28.14	81.03	80.84	36.72	57.24	61.78	4.87	0.69	7.30
2	8.9	16.39	44.53	40.77	19.36	37.69	54.91	5.09	1.08	7.65
6	14.6	10.95	42.84	30.02	13.56	18.10	34.80	12.14	1.32	20.84
3	15.5	5.17	14.20	15.08	13.15	13.06	15.04	3.40	4.02	2.21
7	35.7	4.21	11.72	12.61	6.05	6.90	12.05	1.31	1.06	2.67
4	38.1	3.28	12.06	9.19	5.58	5.41	9.77	0.93	1.36	4.24

SOURCE: Snow Chemistry in the Flin Flon Area of Manitoba, 1981-1983, EMD

Reproduced from Original

TABLE 8-7

MEAN DEPOSITION OF COPPER TO SNOW (mg/m^2), FLIN FLON, MANITOBA
1981 - 1983

Site	Distance (KM)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	47.11	84.14	98.10	71.14	53.29	94.57	11.93	0.23	19.07
5	5.8	99.65	149.18	162.69	38.56	76.14	83.77	13.47	0.18	11.87
2	8.9	2.29	66.41	67.94	21.49	47.21	65.82	6.48	0.28	7.13
6	14.6	9.48	23.60	19.61	10.33	14.05	30.99	2.98	0.33	2.53
3	15.5	12.35	15.30	18.01	10.19	12.58	13.34	4.20	0.45	2.36
7	35.7	2.14	8.14	5.49	0.55	3.44	17.34	0.76	0.25	1.98
4	38.1	2.74	4.74	4.60	1.01	2.03	3.26	0.49	0.34	0.70

SOURCE: Snow Chemistry in the Flin Flon Area of Manitoba, 1981-1983, EMD

Reproduced from Original

TABLE 8-8

MEAN DEPOSITION OF CADMIUM TO SNOW (mg/m^2), FLIN FLON, MANITOBA
1981 - 1983

Site	Distance (KM)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	1.65	1.36	0.58	4.39	5.35	8.33	0.33	0.23	0.26
5	5.8	1.18	1.15	0.34	4.16	4.69	4.39	0.85	0.18	0.40
2	8.9	2.24	1.86	1.25	2.72	3.90	4.71	0.76	0.27	0.26
6	14.6	1.05	2.49	1.34	0.81	1.80	2.01	0.29	0.33	0.22
3	15.5	1.47	1.94	1.37	1.52	0.97	0.97	0.40	0.42	0.22
7	35.7	0.25	1.14	0.48	0.27	0.46	0.93	0.33	0.26	0.50
4	38.1	0.24	0.72	0.42	0.25	0.47	0.65	0.20	0.34	0.35

SOURCE: Snow Chemistry in the Flin Flon Area of Manitoba, 1981-1983, EMD

Reproduced from Original

TABLE 8-9

MEAN DEPOSITION OF LEAD TO SNOW (mg/m^2), FLIN FLON, MANITOBA
1981 - 1983

		1981			1982			1983		
Site	Distance (KM)	Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	25.91	42.48	45.17	40.66	40.60	47.80	1.95	0.44	3.59
5	5.8	55.10	72.99	82.20	19.90	38.47	33.12	4.43	0.18	4.89
2	8.9	25.07	36.32	36.21	12.43	30.72	36.66	3.54	0.27	2.75
6	14.6	5.94	16.32	18.02	5.39	9.23	11.30	1.15	0.33	1.12
3	15.5	10.12	12.50	15.57	7.61	8.22	7.52	1.82	0.50	1.12
7	35.7	2.06	7.56	6.37	1.10	2.86	5.56	0.64	0.26	1.00
4	38.1	1.88	5.29	5.43	1.01	2.03	2.61	0.43	0.34	0.64

SOURCE: Snow Chemistry in the Flin Flon Area of Manitoba, 1981-1983, EMD

Reproduced from Original

TABLE 9-1

METAL CONTENT OF IMMATURE JACK PINE CONES FROM FLIN FLON, 1978

Plot Number	Distance from Stack (km)	Metal Content of Cone (PPM)				
		Pb	Cu	Zn	Cd	Fe
1	5.1 ESE	3.89	13.02	175.8	0.8	93.2
2	8.9 ESE	1.64	7.55	112.22	0.5	52.98
3	15.5 ESE	1.52	7.65	89.1	0.41	42.88
4	38.1 ESE	1.34	7.24	61.78	0.15	44.7
5	5.8 SSE	4.27	12.16	233.6	1.12	75.26
6	14.6 SSE	1.35	6.59	75.46	0.32	49.62
7	35.7 SSE	1.23	6.8	76.6	0.28	48.68
8	38.2 SSE	0.53	12.58	45.84	0.1	31.94

SOURCE: A Preliminary Report on The Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. G. Hogan and D. Wotton. 1980

Reproduced from Original

TABLE 9-2

THE GERMINATION OF CHARACTERISTICS OF JACK PINE SEEDS FROM THE STUDY SITES AS RELATED TO DISTANCE FROM THE SMELTER. FLIN FLON, 1978

Plot Number	Stack Distance (km)	Seed Mass g/400	GERMINANT			NON-GERMINANT		
			Germination (%)	Length (mm)	Mass g/400#	Hollow (%)	Dormant (%)	Rancid (%)
1	5.1	1.00	78.0	54.9	6.54	15.0	4.0	2.0
2	8.9	1.08	72.8	57.0	7.35	18.0	6.0	2.0
3	15.5	1.02	64.2	61.2	8.01	30.0	5.0	1.0
4	38.1	1.16	77.6	57.4	7.82	17.0	5.0	0.0
5	5.8	0.92	68.2	60.7	8.50	25.2	2.6	1.8
6	14.6	1.09	79.0	61.6	8.36	10.6	1.0	8.4
7	35.7	1.19	78.0	68.4	9.03	16.8	1.8	2.0
8	68.2	1.14	75.0	61.2	9.15	17.2	1.6	4.8

GERMINANT MASS STANDARDIZED TO 100% GERMINATION.

SOURCE: A Preliminary Report on The Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils. G. Hogan and D. Wotton. 1980

Reproduced from Original

TABLE 9-3

MERCURY CONCENTRATION (ug/g) IN BLUEBERRY PLANT COMPONENTS AND LFH,
FLIN FLON, 1980 & 1981

Dispersion Sector	Distance (km)	Site No.	Unwashed Berries**		Washed Berries***		Leaves		Stems		Roots		LFH	
			1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
N-NE	2.0	11	0.03	0.03	.01	0.03	0.21	0.21	0.15	0.16	0.08	0.48	7.80	17.80
	4.6	8	0.03	0.02	.01	0.02	0.20	0.34	0.18	0.47	0.06	0.46	4.33	4.38
NE-E	3.2	10	0.04	0.02	.01	0.02	0.30	0.12	0.24	0.10	0.20	0.07	5.36	6.45
E-SE	3.7	9	0.03	0.02	.01	0.02	0.29	0.28	0.55	0.67	0.20	0.08	8.54	22.00
	5.1	1	0.03	0.02	.01	0.02	0.28	0.15	0.44	0.34	0.04	0.03	7.64	10.20
	8.9	2	0.03	0.03	.01	0.03	0.20	0.18	0.20	0.21	0.04	0.04	2.06	12.40
	15.5	3	0.03	0.02	.01	0.02	0.12	0.11	0.11	0.05	0.04	0.03	1.05	3.21
	38.9	4	0.03	0.02	.01	0.02	0.06	0.04	0.04	0.02	0.02	0.03	0.37	0.43
SE-S	2.5	7	0.04	0.02	.01	0.02	0.33	0.57	1.18	5.16	0.07	0.03	10.00	17.80
	5.8	5	0.03	0.02	.01	0.03	0.22	0.13	0.22	0.12	0.04	0.09	24.00	11.70
	14.6	6	0.03	0.02	.01	0.02	0.07	0.04	0.09	0.07	0.04	0.05	1.36	1.43

* Distance from HBM&S complex

** Wet Weight Value - adjusted to a 70% water content

LFH: Litter Fermentation Humification Zone (Surface Organic Layer of Soil)

*** Corrected from Original

Reproduced from Original

TABLE 9-4

LEAD CONCENTRATION (ug/g) IN BLUEBERRY PLANT COMPONENTS AND LFH,
FLIN FLON, 1980 & 1981

Dispersion Sector	Distance (km)	Site No.	Unwashed Berries**		Washed Berries**		Leaves		Stems		Roots		LFH	
			1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
N-NE	2.0	11	1.02	2.31	0.69	1.29	12.0	18.0	32.0	60.0	10.0	3.2	1100.0	1600.0
	4.6	8	1.47	1.36	0.77	1.23	11.0	17.0	30.0	39.0	32.0	51.0	620.0	500.0
NE-E	3.2	10	1.31	1.48	0.49	2.00	20.0	--	59.0	36.0	23.0	74.0	940.0	770.0
E-SE	3.7	9	1.50	0.72	1.50	0.71	21.0	12.0	220.0	55.0	29.0	17.0	1500.00	950.0
	5.1	1	1.57	1.18	1.35	0.54	31.0	12.0	110.0	31.0	55.0	100.0	720.0	570.0
	8.9	2	0.36	0.72	0.58	0.74	20.0	12.0	85.0	44.1	16.0	30.0	430.0	560.0
	15.5	3	0.60	0.63	0.54	0.69	8.4	8.7	24.0	26.0	19.0	8.08	220.0	200.0
	38.9	4	0.29	0.48	0.19	0.57	5.9	2.9	12.0	6.1	4.7	2.5	120.0	51.0
SE-S	2.5	7	0.81	0.70	0.66	0.72	23.0	18.0	56.0	200.0	44.0	40.0	1200.0	910.0
	5.8	5	0.66	0.57	1.36	0.62	25.0	16.0	110.0	61.0	9.4	7.3	1600.0	1400.0
	14.6	6	0.51	0.63	0.52	0.57	12.0	15.0	68.0	45.0	43.0	32.0	470.0	630.0

* Distance from HBM&S complex

** Wet Weight Value - adjusted to a 70% water content

LFH: Litter Fermentation Humification Zone (Surface Organic Layer of Soil)

Reproduced from Original

TABLE 10-1

SAMPLING LOCATIONS AND YEARS OF MAMMAL COLLECTION

Zone	1			2				3			4		5
Distance from smelter(km)	4	5.1	5.8	8.9	11	14.6	15.5	35.7	37	38.1	61	68	185
Azimuth (degrees)	135	100	158	126	135	172	110	166	159	131	151	82	109
Blood Sampling Years	81	78	78	78	81	78	78	78	81	78	81	78	77/79/81
Tissue Collection Years	81/82			81/82				81/82					81/82

SOURCE: Monitoring Smelter Emissions Using Small Mammals as Indicators. Kucera, 1983. EMD

Reproduced from Original

TABLE 10-2

BLOOD VALUES OF PEROMYSCUS MANICULATUS (DEER MICE) AT VARIOUS DISTANCES FROM FLIN FLON SMELTER[1]

	Hemoglobin (g/100ml)	Packed Cell Volume (%)	$100 \times \frac{MCHC\ Hb}{PCV}$
Zone 1 n=19	14.59^{a}	44.3^{a}	33.1^{a}
Zone 2 n=53	14.46^{a}	45.2^{a}	$32.0^{a,b}$
Zone 3 n=33	14.28^{a}	45.4^{a}	$30.5^{b,c}$
Zone 4 n=12	$13.49^{a.b}$	45.3^{a}	29.7^{c}
Zone 5 n=44	12.41^{b}	40.7^{b}	$30.7^{b,c}$

[1] Means adjusted for plasma proteins and parasite infestation. Within each column, means with different superscripts are significantly different.

SOURCE: Monitoring Smelter Emissions Using Small Mammals as Indicators. Kucera, 1983. EMD

Reproduced from Original

TABLE 10-3

METAL CONCENTRATIONS[1] IN TISSUES OF PERMYSCUS MANICULATUS (DEER MICE) COLLECTED AT VARIOUS DISTANCES FROM HBM&S SMELTER

		Hide As		Hide Zn	Hide Cu	Carcass Co	Carcass Pb
Zone 1 (4km)	n=7	1.54[a]	n=14	132.5[a]	14.6[a]	2.21	13.80[a]
Zone 2 (11 km)	n=10	0.92[b]	n=44	112.8[b]	11.4[b]	2.09[a,b]	8.04[b]
Zone 3 (37 km)	n=8	0.26[c]	n=28	140.7[a]	10.0[b,c]	1.81[b]	3.12[c]
Zone 4 (61 km)	n=4	0.37[c]	n=9	117.0[b]	9.0[c]	1.81[b]	3.20[c]
Zone 5 (185 km)	n=5	0.20[c]	n=33	101.7[b]	9.4[c]	2.25[a]	5.30[c]

[1] Within each column, means with different superscripts are significantly different.

SOURCE: Monitoring Smelter Emissions Using Small Mammals as Indicators. Kucera, 1983. EMD

* Metal Contents Expressed In PPM

Reproduced from Original

TABLE 10-4

CATCH OF DEER MICE AND VOLES (ANIMALS/100 TRAP NIGHTS)

ZONE	1	2	3	4	5
Voles					
1978	0	0	0.01	0.01	0.91
1981	0	0.27	0.94	1.08	4.57
1982	0	0.86	0	0	----
Deer Mice					
1978	0.02	0.02	0.03	0.01	3.77
1981	1.08	3.76	3.09	0.57	4.57
1982	2.86	8.86	0.71	0.57	4.57
Vole: mouse ratio					
1978	0	0	0.33	1.00	0.24
1981	0	0.07	0.30	1.5	1.00
1982	0	0.10	0	0	----
Overall V:M ratio	0	0.06	0.21	0.87	0.62

SOURCE: Monitoring Smelter Emissions Using Small Mammals as Indicators. Kucera, 1983. EMD

Reproduced from Original

TABLE 10-5

MEAN HEMOGLOBIN (GB; g/100 ml) AND HEMATOCRITE (PCV; %) VALUES OF PEROMYSCUS MANICULATUS

PLOT NO.	1	5	2	6	3	7	4	8	14
Distance (km)	5.1	5.8	8.9	14.6	15.5	35.7	38.1	68.2	185.50
Direction	ESE	SSE	ESE	SSE	ESE	SSE	ESE	ENE	ESE
Azimuth (degree)	100	158	126	172	110	166	131	82	109
No. of Animals	4	12	13	17	11	11	7	8	51
Mean Hb	16.00	14.95	14.98	14.37	15.29	13.65	15.00	13.09	12.85
SD	2.73	2.77	1.43	1.88	1.60	3.69	1.73	3.45	1.70
Range (upper)	19.8	18.0	17.8	16.2	16.4	18.5	18.5	16.5	16.6
(lower)	13.5	7.6	12.3	9.4	11.0	6.5	13.4	6.8	7.2
Mean PCV	47.00	45.88	45.62	44.18	48.09	43.64	47.29	42.06	42.00
SD	6.38	9.88	3.93	5.51	5.23	10.19	6.58	8.74	5.23
Range (upper)	56.0	58.0	53.0	51.0	53.5	56.0	59.0	53.0	54.0
(lower)	41.0	24.0	40.5	32.0	33.0	23.5	40.0	34.0	23.5

SOURCE: Emissions distribution reflected in wild rodent tissues. Submission to Manitoba Clean Environment Commission. Kucera, 1980. EMD

Reproduced from Original

TABLE 11-1

COMPARISON (t = 0.05) OF GENERAL PHYSICIAL MERISTICS AND MUSCLE TISSUE METALS LEVELS IN TROUT LAKE AND CLIFF LAKE FISH.

Student "t" Values (Significantly greater by Lake)

Parameters	Walleye	Northern Pike	Lake Whitefish
Length	1.38	0.15	0.16
Weight	0.78	0.02	2.04
Age	0.01	0.41	2.37 (Cliff L.)
Hg	2.06	0.39	10.08 (Trout L.)
As	4.02 (Cliff L.)	1.46	3.33 (Trout L.)
Cd	0.0	0.0	0.0
Cu	0.13	1.74	3.0 (Cliff L.)
Pb	1.11	0.0	0.0
Ni	1.11	1.49	0.0
Zn	0.60	3.10 (Cliff L.)	2.37 (Cliff L.)
Critical Value (T = 0.05)	2.09	2.02	2.07

SOURCE: A Background Study of Trout (Embury) and Cliff Lake. Wilson, 1984. EMD

* Metal Content Expressed In PPM

Reproduced from Original

TABLE 11-2

SUMMARY OF GENERAL PHYSICAL MERISTICS AND MUSCLE TISSUE METAL LEVELS, TROUT LAKE FISH

Statistic*	Length (cm)	Weight (g)	Age (Yrs)	Muscle Tissue Metal Levels (ug/g wet weight) Hg	As	Cd	Cu	Pb	Ni	Zn
Walleye (N = 11)										
X	54.72	1756	12.82	0.54	0.05	0.1	0.38	0.53	0.5	5.38
SD	3.72	419.7	3.43	0.15	0.01	0.0	0.24	0.09	0.0	1.54
Hi	641	2900	17	0.68	0.07	0.1	0.7	0.08	0.5	9.5
Lo	492	1330	7	0.25	0.02	0.1	0.1	0.5	0.5	3.6
Northern Pike (N = 20)										
X	54.76	1287.5	4.70	0.35	0.11	0.1	0.27	0.5	0.5	4.75
SD	10.34	1647.2	2.36	0.33	0.09	0.0	0.18	0.0	0.0	1.02
Hi	95.6	8220	14	1.66	0.31	0.1	0.5	0.5	0.5	7.8
Lo	48.4	650	3	0.14	0.02	0.1	0.1	0.5	0.5	3.6
Lake Whitefish (N = 21)										
X	34.51	463.8	9.38	0.13	0.19	0.1	0.24	0.5	0.5	3.99
SD	6.68	315.2	3.97	0.05	0.19	0.0	0.12	0.0	0.0	0.69
Hi	44.8	1000	15	0.22	0.76	0.1	0.4	0.5	0.5	5.7
Lo	24.8	100	5	0.06	0.03	0.1	0.1	0.5	0.5	3.1
Common Sucker (N = 19)										
X	47.79	1533.7	10.11	0.051	0.04	0.1	0.36	0.5	0.5	6.19
SD	3.78	410.4	2.40	0.026	0.017	0.0	0.28	0.0	0.0	2.35
Hi	53.2	2250	15	0.11	0.08	0.1	0.1	0.5	0.5	10.0
Lo	41.7	1040	6	0.02	0.02	0.1	0.1	0.5	0.5	3.4
Lake Trout (N = 21)										
X	49.73	1257.6	8.33	0.24	0.10	0.1	0.36	0.5	0.5	4.60
SD	5.07	247.9	4.70	0.15	0.05	0.0	0.20	0.0	0.0	0.98
Hi	58.6	1860	21	0.65	0.18	0.1	0.9	0.5	0.5	5.8
Lo	42.0	750	3	0.12	0.02	0.1	0.1	0.5	0.5	3.2

Note: X = mean
SD = standard deviation
Hi = greatest value
Lo = smallest value

SOURCE: A Background Study of Trout (Embury) and Cliff Lake. Wilson, 1984. EMD

Reproduced from Original

TABLE 11-3

SUMMARY OF GENERAL PHYSICAL MERISTICS AND MUSCLE TISSUE METAL LEVELS, CLIFF LAKE FISH

Statistic*	Length (cm)	Weight (g)	Age (Yrs)	Muscle Tissue Metal Levels (ug/g wet weight) Hg (Wet)	As	Cd	Cu	Pb	Ni	Zn
Walleye (N = 11)										
X	51.46	1586.0	12.80	0.39	0.09	0.1	0.37	0.5	0.53	5.45
SD	6.56	563.1	3.85	0.18	0.03	0.0	0.09	0.0	0.09	1.38
Hi	62.0	2450	19	0.66	0.13	0.1	0.5	0.5	0.8	7.9
Lo	42.2	860	5	0.13	0.03	0.1	0.3	0.5	0.5	3.8
Northern Pike (N = 20)										
X	55.21	1277.5	4.95	0.32	0.08	0.1	0.35	0.5	0.52	6.16
SD	8.03	1069.6	0.32	0.10	0.02	0.0	0.10	0.0	0.06	1.76
Hi	87.0	5760	9	0.44	0.11	0.1	0.5	0.5	0.7	11.5
Lo	48.3	800	4	0.19	0.04	0.1	0.1	0.5	0.5	3.8
Lake Whitefish (N = 21)										
X	34.18	655	14.75	0.02	0.03	0.1	0.45	0.5	0.5	5.33
SD	2.98	126.9	4.19	0.0	0.01	0.0	0.13	0.0	0.0	1.09
Hi	37.7	800	21	0.02	0.05	0.1	0.06	0.5	0.5	6.4
Lo	31.3	500	12	0.02	0.02	0.1	0.03	0.5	0.5	4.0

Note: X = mean
SD = standard deviation
Hi = greatest value
Lo = smallest value

SOURCE: A Background Study of Trout (Embury) and Cliff Lake. Wilson, 1984. EMD

Reproduced from Original

TABLE 13-1

LEVELS OF HEAVY METALS IN FLIN FLON DRINKING WATER

		FLIN FLON RAW WATER 1980	FLIN FLON TREATED 1980	THE PAS RAW 1980	CHURCHILL RAW 1980	FLIN FLON RAW 1983	FLIN FLON TREATED 1983	MAX ACC*	BASIS*	OBJECTIVE*
pH	Units	7.3	7.0	7.8	7.4	7.25	7.45	6.5-8.5	A	-
AS (Ext)	mg/l	0.005	0.005	0.001	0.001	0.003	0.002	0.05	H	0.005
B (Diss)	mg/l	0.10	0.10	0.10	0.01	0.05	0.01	5.0	H	0.01
Cd (Ext)	mg/l	0.005	0.005	0.005	0.005	0.001	0.001	0.005	H	0.001
Cu (Ext)	mg/l	0.01	0.015	0.01	0.021	0.011	0.07	1.0	A	1.0
Pb (Ext)	mg/l	0.015	0.005	0.02	0.005	0.005	0.005	0.05	H	0.001
Zn (Ext)	mg/l	0.44	0.41	0.02	0.95	0.32	0.35	5.0	A	5.0
Hg (Ext)	ug/l	0.03	0.02	0.02	0.02	0.02	0.02	1.0	H	0.02
Ca (Ext)	mg/l	13	13	47	15	15.4	15.6	-	-	-
Mg (Ext)	mg/l	5.0	5.0	18	5.0	4.23	4.50	-	-	-
Mn (Ext)	mg/l	0.02	0.04	0.02	0.02	0.02	0.02	0.05	A	0.01
Fe (Ext)	mg/l	0.04	0.05	0.27	0.19	0.09	0.05	0.3	A	0.05
Na (Ext)	mg/l	10.0	10.0	20.0	10.0	1.80	1.85	-	-	-
Color	Units	-	-	-	-	15	10	15	A	15
Turbidity	NTU	-	-	-	-	0.90	0.50	5	H+A	1
F	mg/l	0.1	0.1	0.33	0.1	0.1	0.1	1.5	H+A	1.0
SO_4 (Sol)	mg/l	15	15	66	7.0	12.2	12.8	500	H+A	150
CN (Free)	mg/l	0.02	0.02	0.02	0.02	0.02	0.02	0.02	H	0.002
Cl (Sol)	mg/l	2.0	2.0	11	2.0	2.0	2.0	250	A	250

SOURCE: Unpublished EMD documents

***SOURCE:** Guidelines for Canadian Drinking Water Quality 1978
Health and Welfare Canada

Max acc: Maximum acceptable concentration
basis: H-health A-aesthetic
objective:objective concentration

Reproduced from Original

TABLE 13-2

SUMMARY OF TROUT LAKE AND CLIFF LAKE WATTER PHYSICOCHEMISTRY AND SEDIMENT ANALYSIS (1981)

	Water Physiocochemistry			Sediment Analysis	
	Cliff Lake (mean of 15 samples)	Trout Lake (mean of 30 samples)		Cliff Lake (mean of 15 samples)	Trout Lake (mean of 30 samples)
Turbidity NTU	1.20	1.3	Hg (Wet) ug/g	0.34*	0.136
Cyanide (Free mg/1)	0.02	0.02	Hg (dry) ug/g	0.22*	0.402
As (Tot) mg/1	0.004*	0.002	As (ug/g)	107.	175.**
Cd (Ext.) mg/1	0.005	0.005	Cd (ug/g)	17.*	10.
Cu (Ext.) mg/1	0.032	0.024	Cu (ug/g)	620*	318
Pb (Ext.) mg/1	0.005	0.005	Pb (ug/g)	396.*	266.
Ni (Ext.) mg/1	0.006	0.007	Ni (ug/g)	44.	67.**
Zn (Ext.) mg/1	0.39*	0.30	Zn (ug/g)	2922.*	1502.
Ca (Ext.) mg/1	15.	16.	Fe (%)	3.27	5.26**
Mg (Ext.) mg/1	4.6*	4.3	Mn (ug/g)	563.	5432**
Hg (Tot.) ug/1	0.02	0.03**	Cyanide (ug/g)	1	1

* Significantly higher than Trout Lake

** Significantly higher than Cliff Lake

Critical Value (t = 0.05)

SOURCE: A Background Study of Trout (Embury) and Cliff Lakes. Wilson, 1984. EMD

Reproduced from Original

Demonstration of Heavy Metal Gradient Surrounding HBM&S Smelter at Flin Flon

TABLE 14-1

Location of Station	Source 1 Metal Content of Mature jackpine cones, 1978 (µg/g)			Source 2 Lead Conc. in Blueberries and soil, 1980 and 1981 (µg/g)				Source 3 # of Lichen species		Source 4 Mean Hb of deer mice	Source 5 Accumulation of zinc and lead in snow (µg/m²) for winters of 80-81, 81-82 and 82-83					
				Unwashed berries		soil		1978	1983	1980						
	Pb	Zn	Fe	1980	1981	1980	1981				Zn	Pb	Zn	Pb	Zn	Pb
3.7 km ESE	-	-	-	1.50	0.72	1500.0	950.0	-	-	-	-	-	-	-	-	-
5.1 km ESE	0.79	24.2	13.8	1.57	1.18	720.0	570.0	1	1	16.00	1450	26	2658	41	50	2
8.9 km ESE	0.85	24.6	12.9	0.63	0.72	430.0	560.0	1	0	14.98	1343	25	704	12	95	4
15.5 km ESE	0.66	15.7	8.7	0.60	0.63	220.0	200.0	1	1	15.26	409	10	254	8	34	2
38.1 km ESE	0.52	8.8	8.1	-	-	-	-	8	9	15.00	55	2	14	1	3	0.4
38.9 km ESE	-	-	-	0.29	0.48	120.0	51.0	-	-	-	-	-	-	-	-	-
185. km ESE	-	-	-	-	-	-	-	-	-	12.85	-	-	-	-	-	-
5.8 km SSE	0.76	32.9	12.3	-	-	-	-	0	1	14.95	3083	55	1322	20	129	4
14.6 km SSE	0.52	16.9	9.6	-	-	-	-	5	3	14.37	277	6	153	5	15	1
35.7 km SSE	0.50	16.3	11.6	-	-	-	-	6	9	13.65	42	2	10	1	5	0.6

Source 1: A Preliminary Report On The effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils Submission to Clean Environment Commission.
G. Hogan and D. Wotton May, 1980
Table 17 Metal Content of Mature Jackpine cones from Flin Flon, 1978

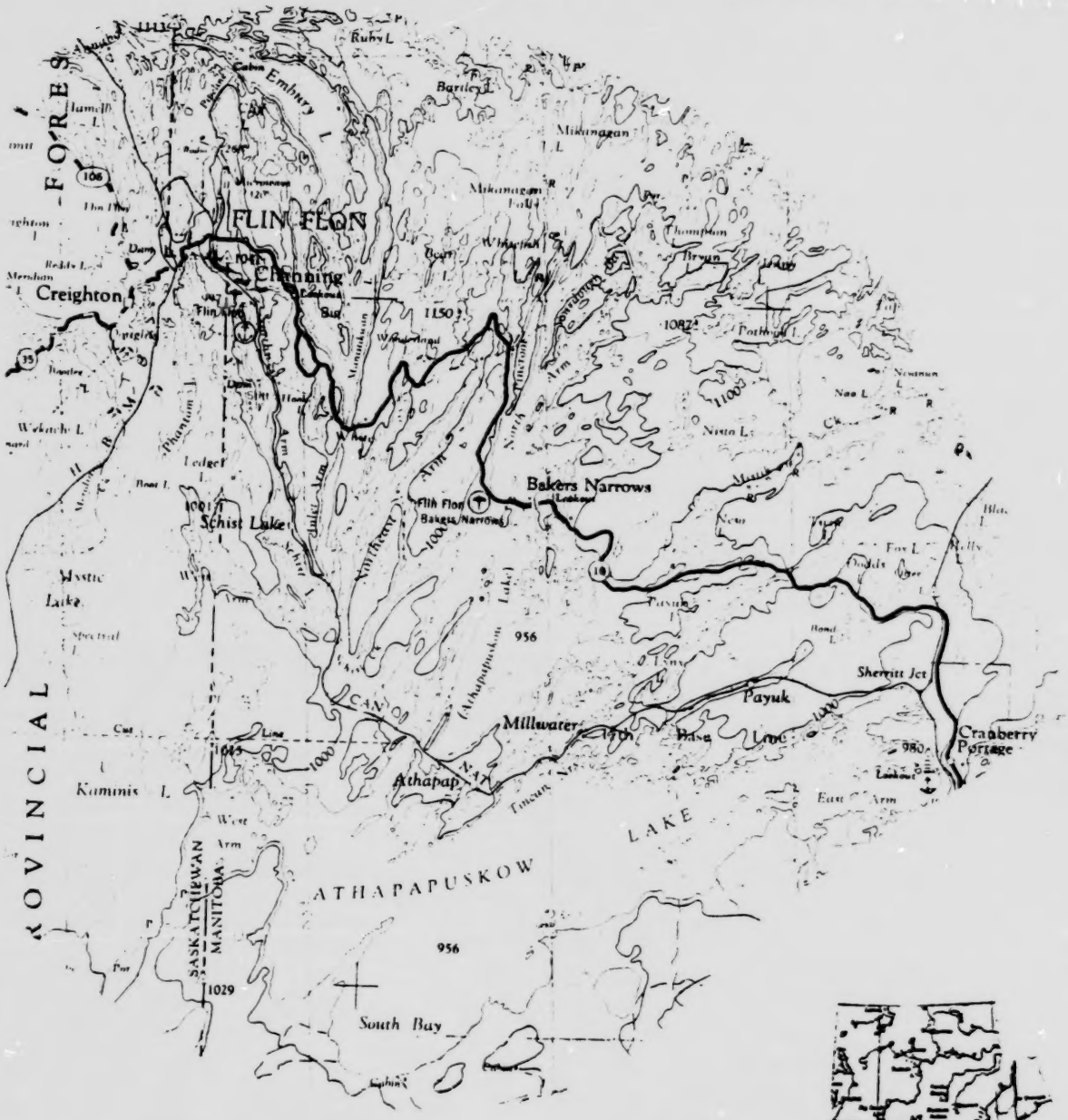
Source 2: Monitoring for Mercury and Lead in Blueberry Plants (Vaccinium myrtilloides (Michx)) of the Flin Flon Area.
D.B. McEachern and S.F. Phillips Report 83-12 Dec 1983
Table 2 Lead Concentration in Blueberry Plant Components, Flin Flon, 1980 and 1981.

Source 3: A Study of Forest Vegetation in the Flin Flon Area for Atmospheric Emission Effects from the HBM&S Smelter
D. Wotton, D. McEachern and D. Jones Report 83-11 Nov 1983 Figure 4

Source 4: Emissions Distribution Reflected in Wild Rodent Tissues Submission to the MCEC
Emil Kucera, Ph.d. May 1980 Table 2

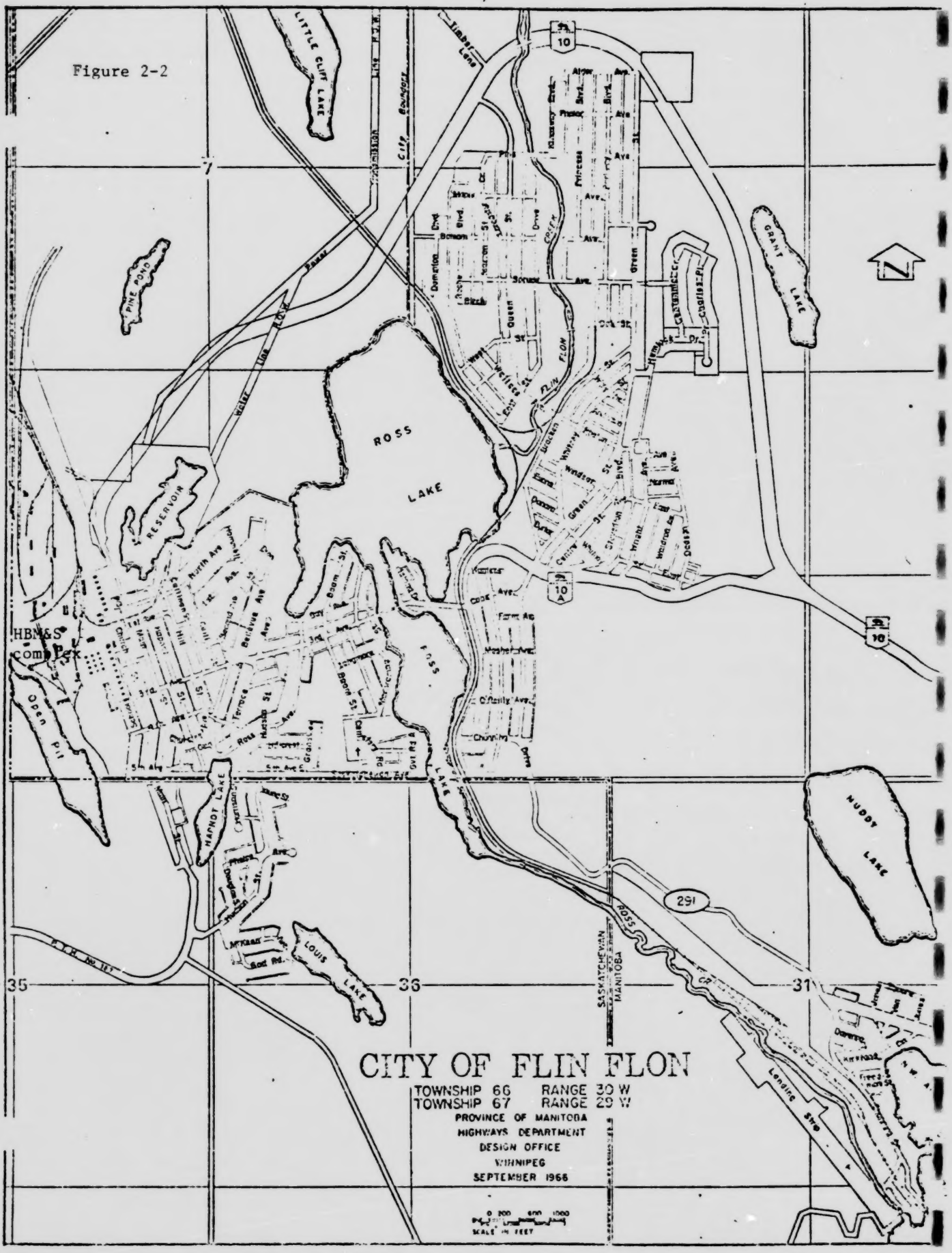
Source 5: Snow Chemistry in the Flin Flon Area of Manitoba Report 83-13 Dec 1983 Table 1
S.F. Phillips, D.L. Wotton, D.B. McEachern and D.C. Jones

Figure 2-1 **LOCATION OF FLIN FLON IN MANITOBA**



Flin Flon Area

Figure 2-2



CITY OF FLIN FLON

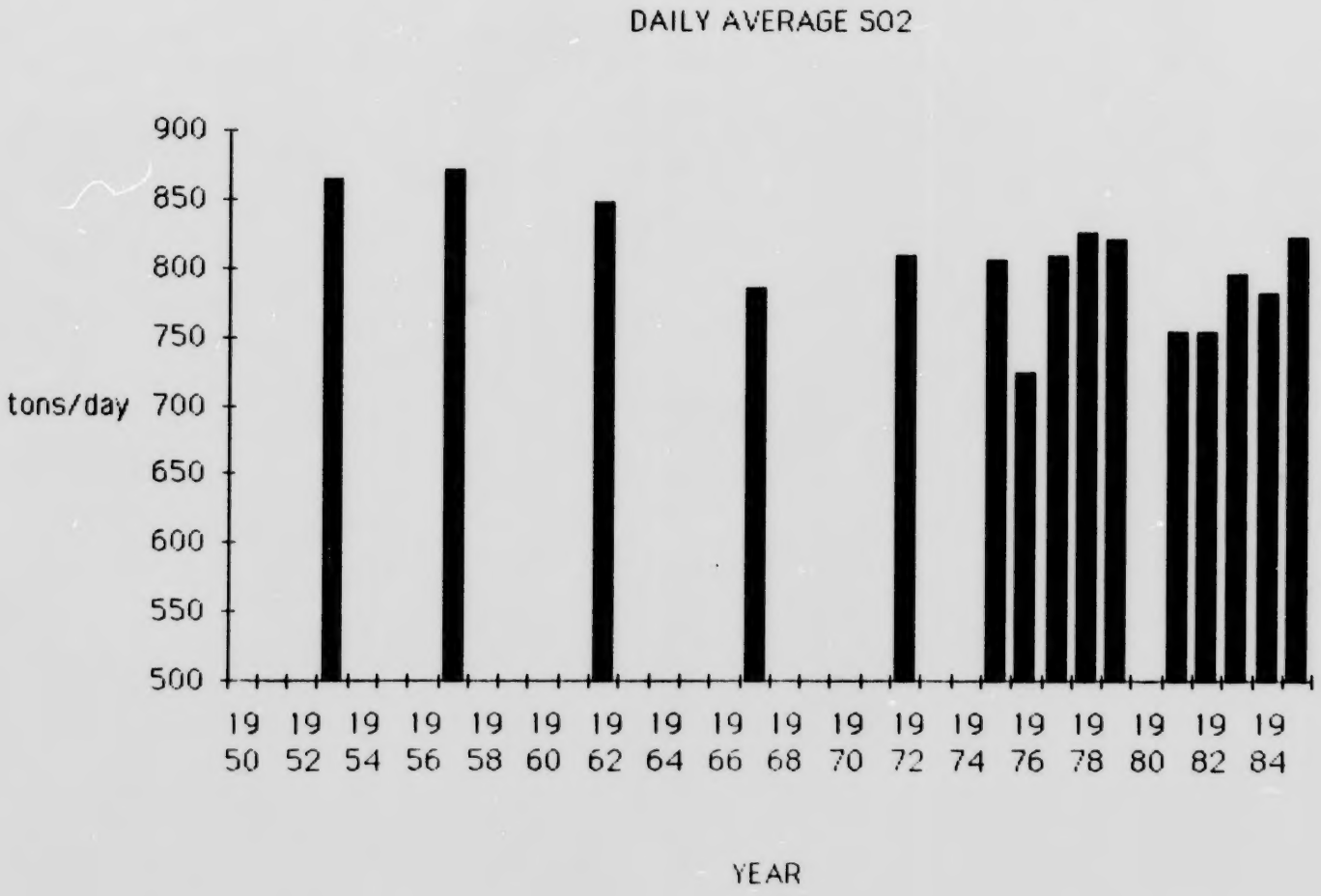
TOWNSHIP 66 RANGE 30 W
TOWNSHIP 67 RANGE 29 W

PROVINCE OF MANITOBA
HIGHWAYS DEPARTMENT
DESIGN OFFICE
WINNIPEG
SEPTEMBER 1966

SCALE IN FEET

Figure 5-1

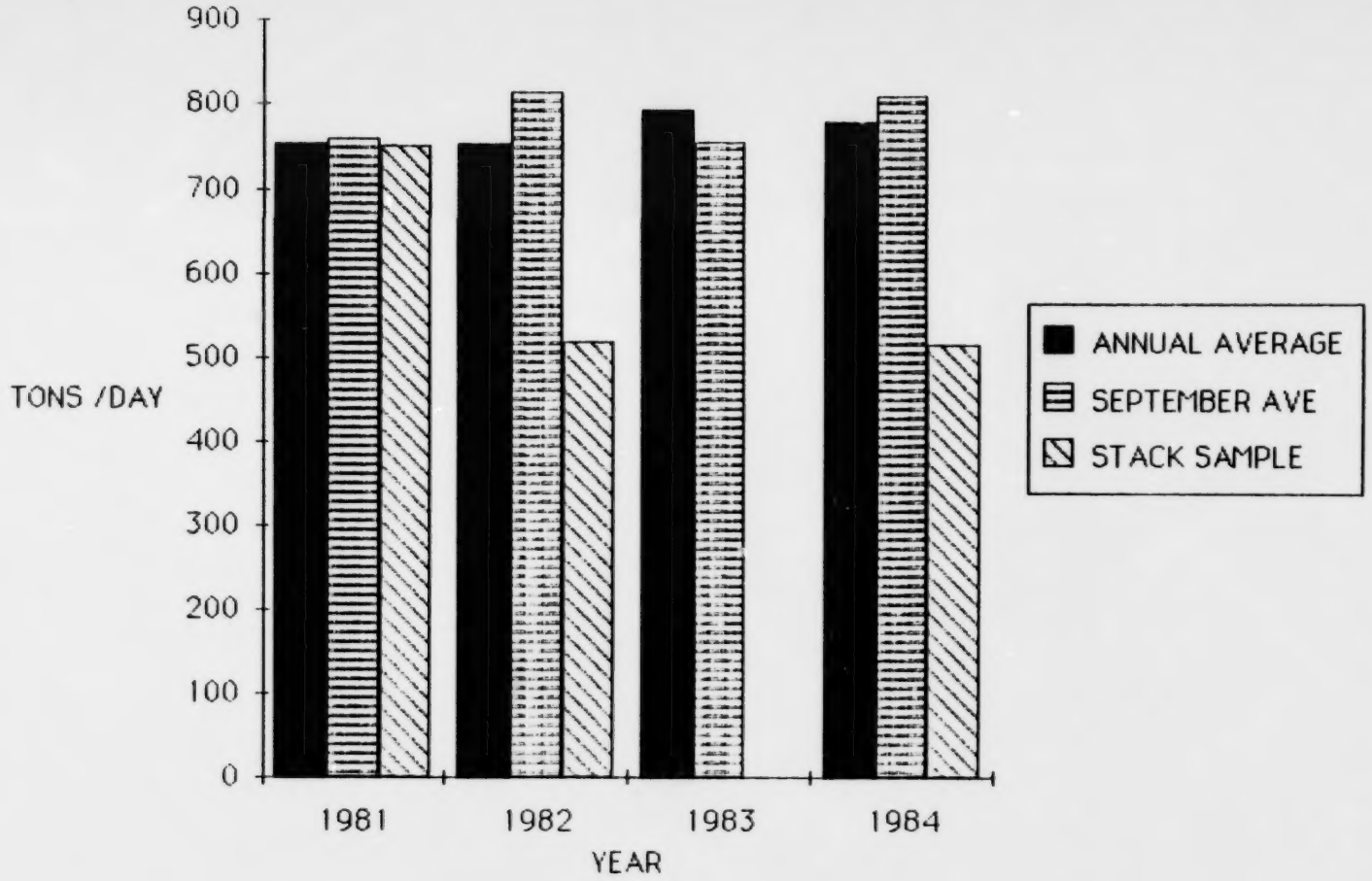
MASS BALANCE CALCULATIONS FOR SO2



5 year averages for the period 1950-74, and annual averages for 1975-84

Figure 5-2

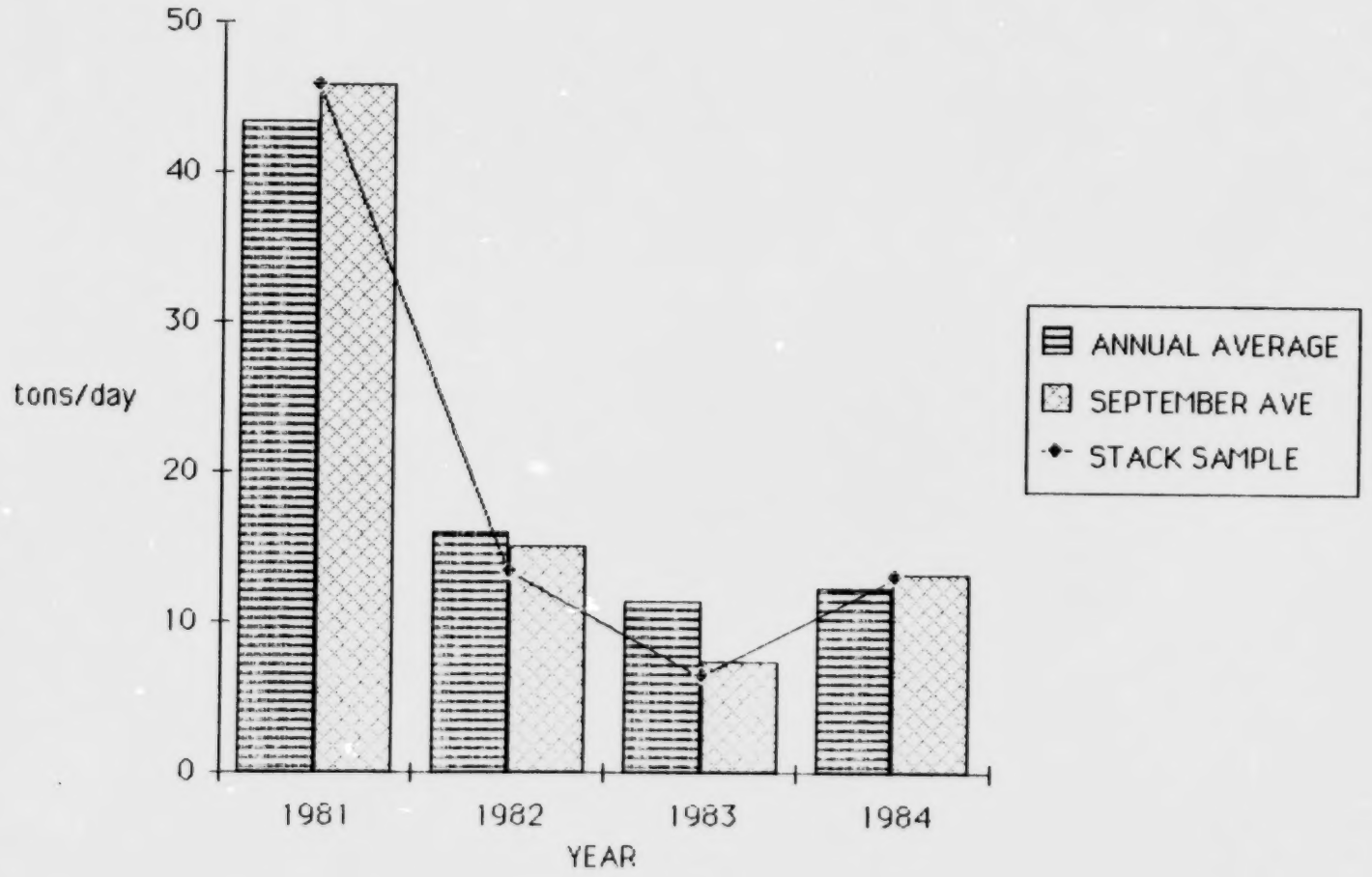
SO2 EMISSIONS (1981-84): COMPARISON OF STACK SAMPLING AND MASS CALCULATIONS



RESULTS OF STACK SAMPLING FOR 1983 NOT AVAILABLE

PARTICULATE EMISSION (1981-84): COMPARISON OF STACK SAMPLING AND MASS BALANCE CALCULATIONS

Figure 5-3



IN 1983, THE AUGUST AVERAGE INSTEAD SEPTEMBER

Figure 5-4

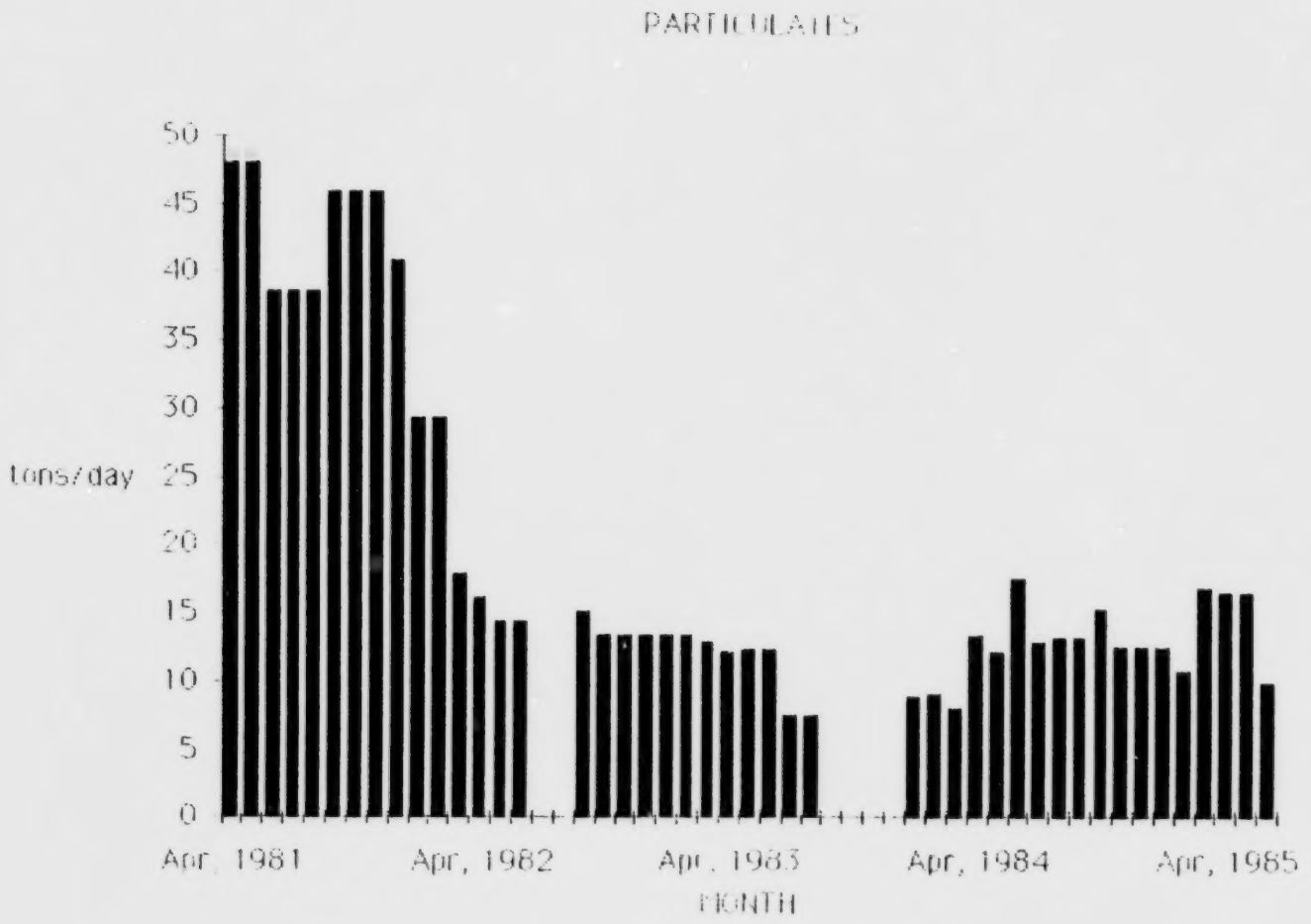
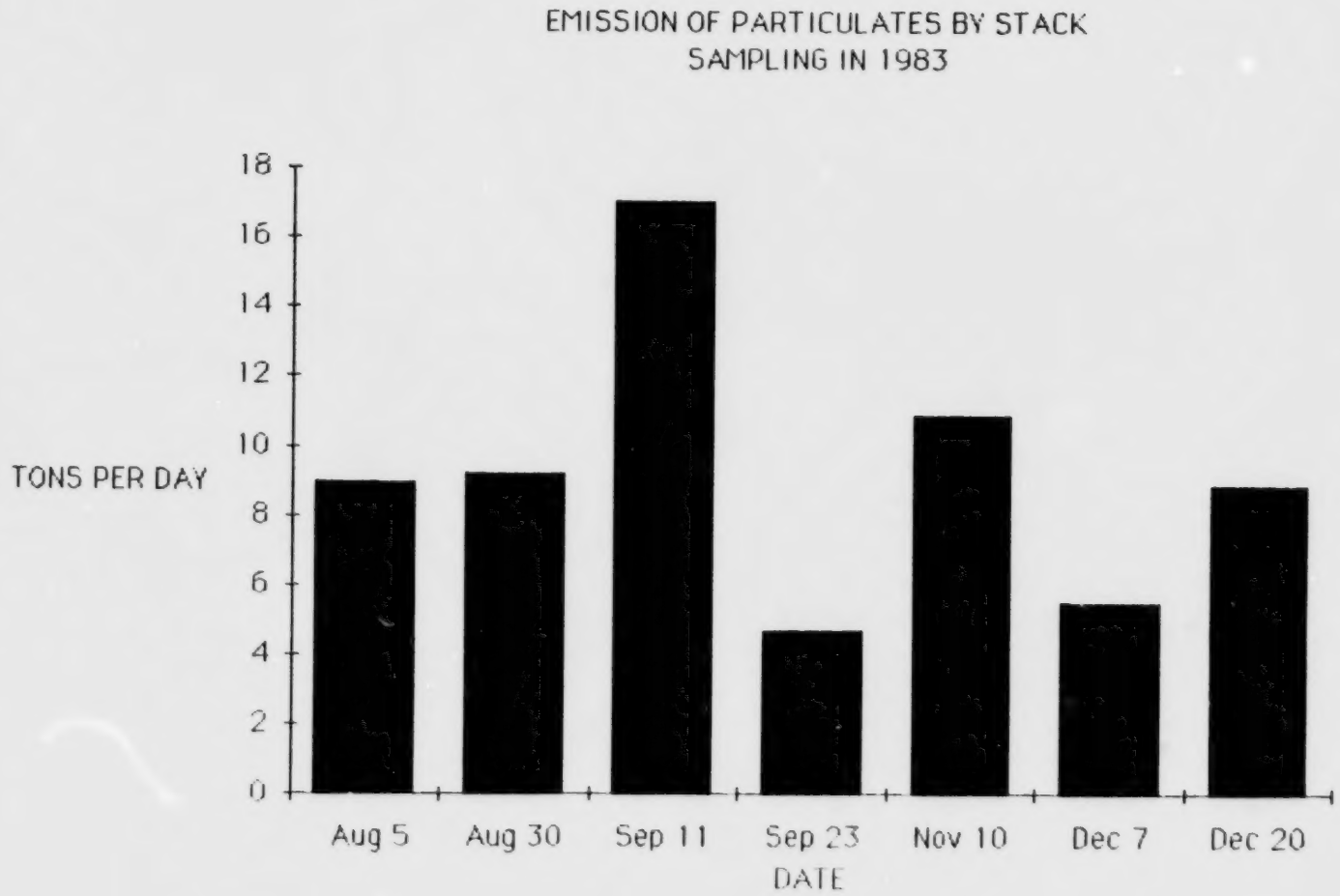

PARTICULATES
50
45
40
35
30
25
20
15
10
5
0
tons/day
Apr, 1981
Apr, 1982
Apr, 1983
Apr, 1984
Apr, 1985
MONTH

Figure 5-5

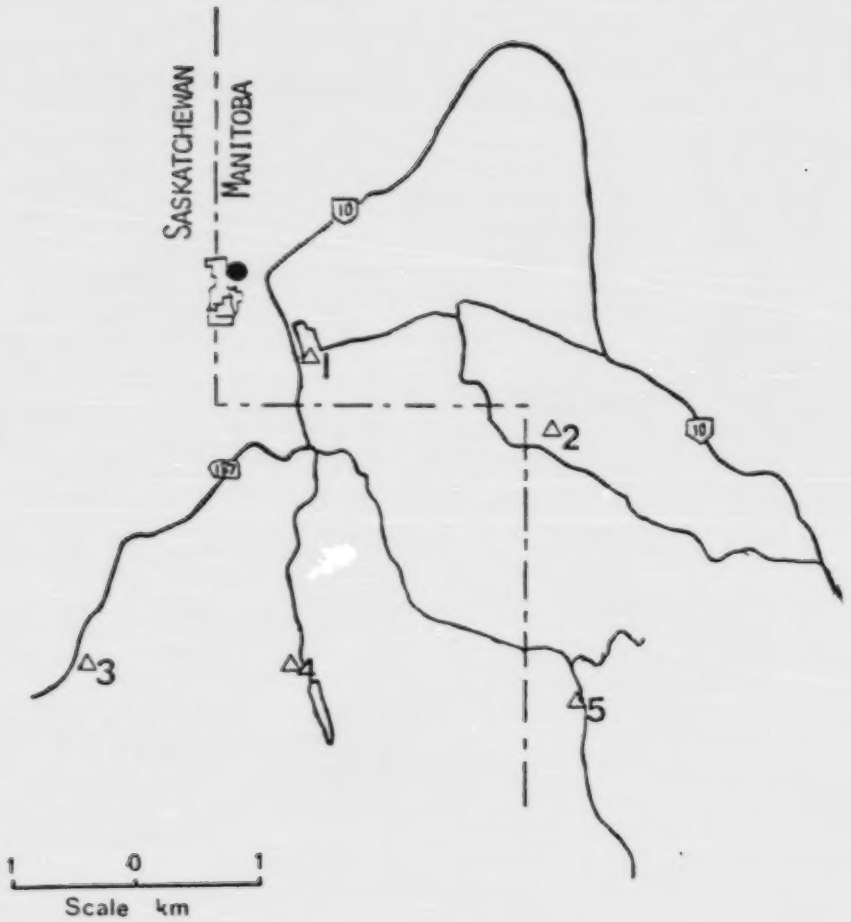


SOURCE: W. FRASER, HBH

Figure 6-1

LEGEND:

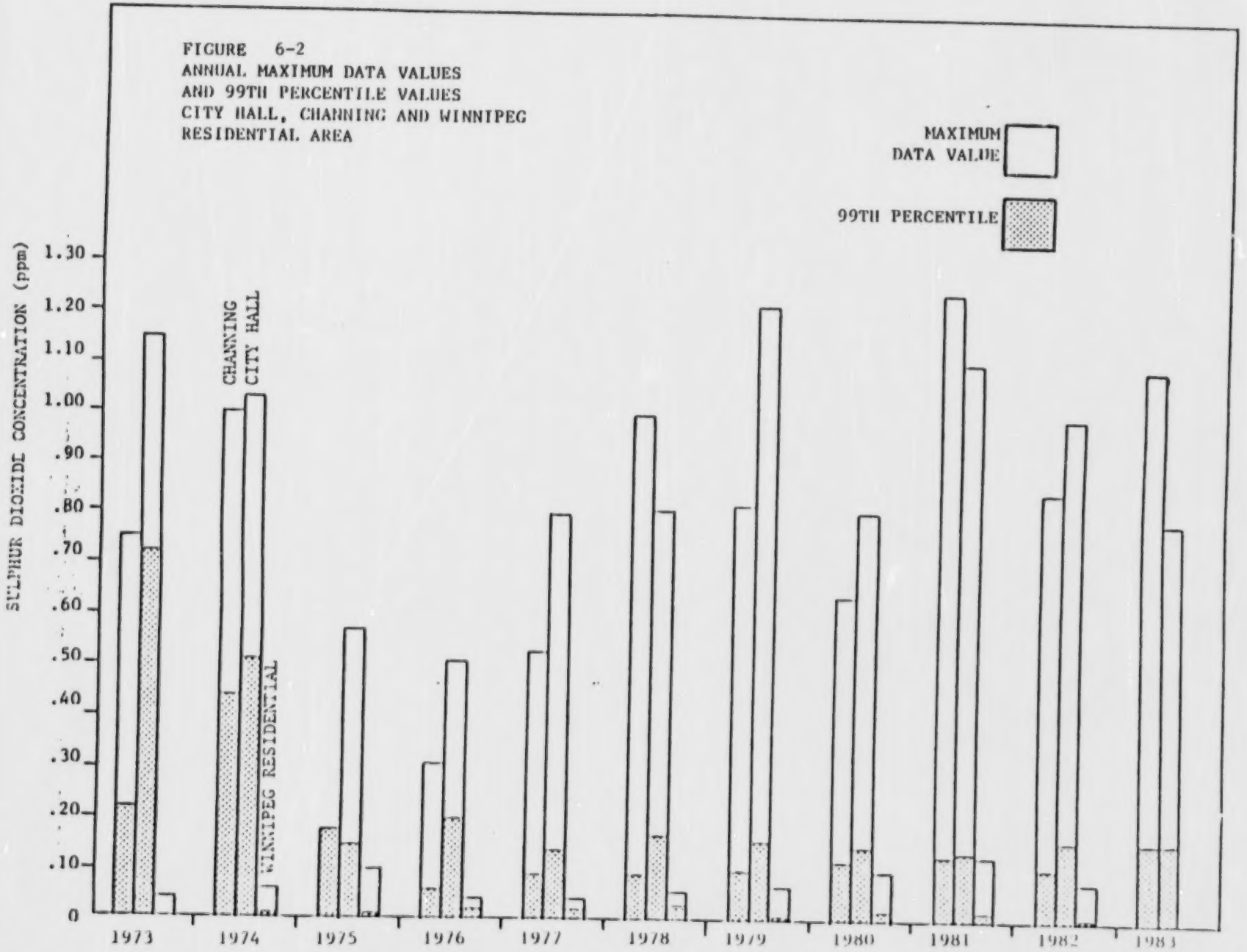
- ● HBMS 250 M STACK
1. CITY HALL, EMD, .71 KM SE
2. CHANNING, EMD, 3.1 KM ESE
3. CREIGHTON, HBMS, 3.5 KM SSW
4. PHANTOM LAKE, HBMS, 3.2 KM S
5. HUDSON BAY AIRPORT, HBMS, 4.5. KM SSE



SO_2 MONITORING SITES
FLIN FLON AREA

Source: Ambient Air Sulphur Dioxide Levels in The Flin Flon, Manitoba Area, MEMD

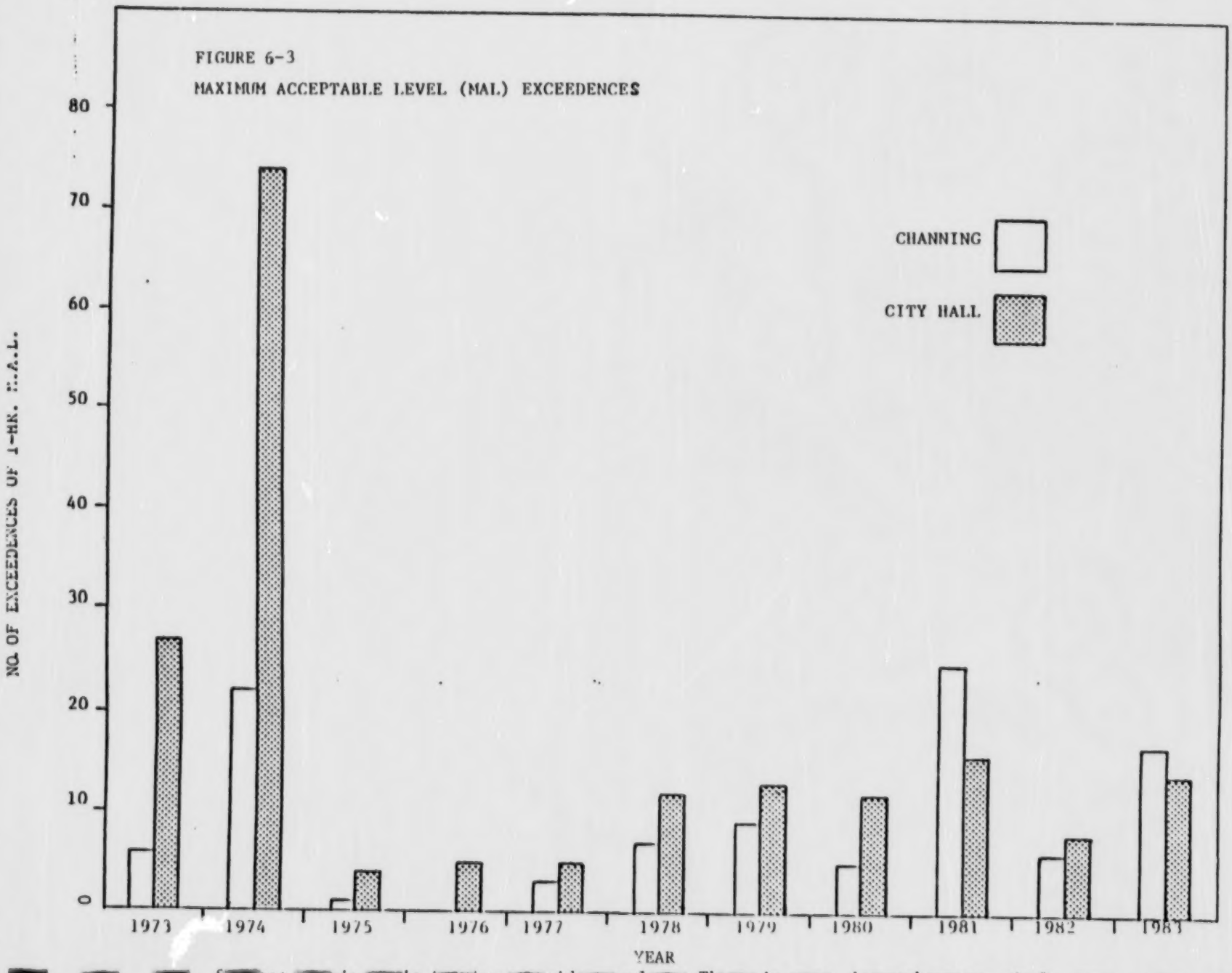
FIGURE 6-2
ANNUAL MAXIMUM DATA VALUES
AND 99TH PERCENTILE VALUES
CITY HALL, CHANNING AND WINNIPEG
RESIDENTIAL AREA



Source: Ambient Air Sulphur Dioxide Levels in the Flin Flon, Manitoba Area, MEMD

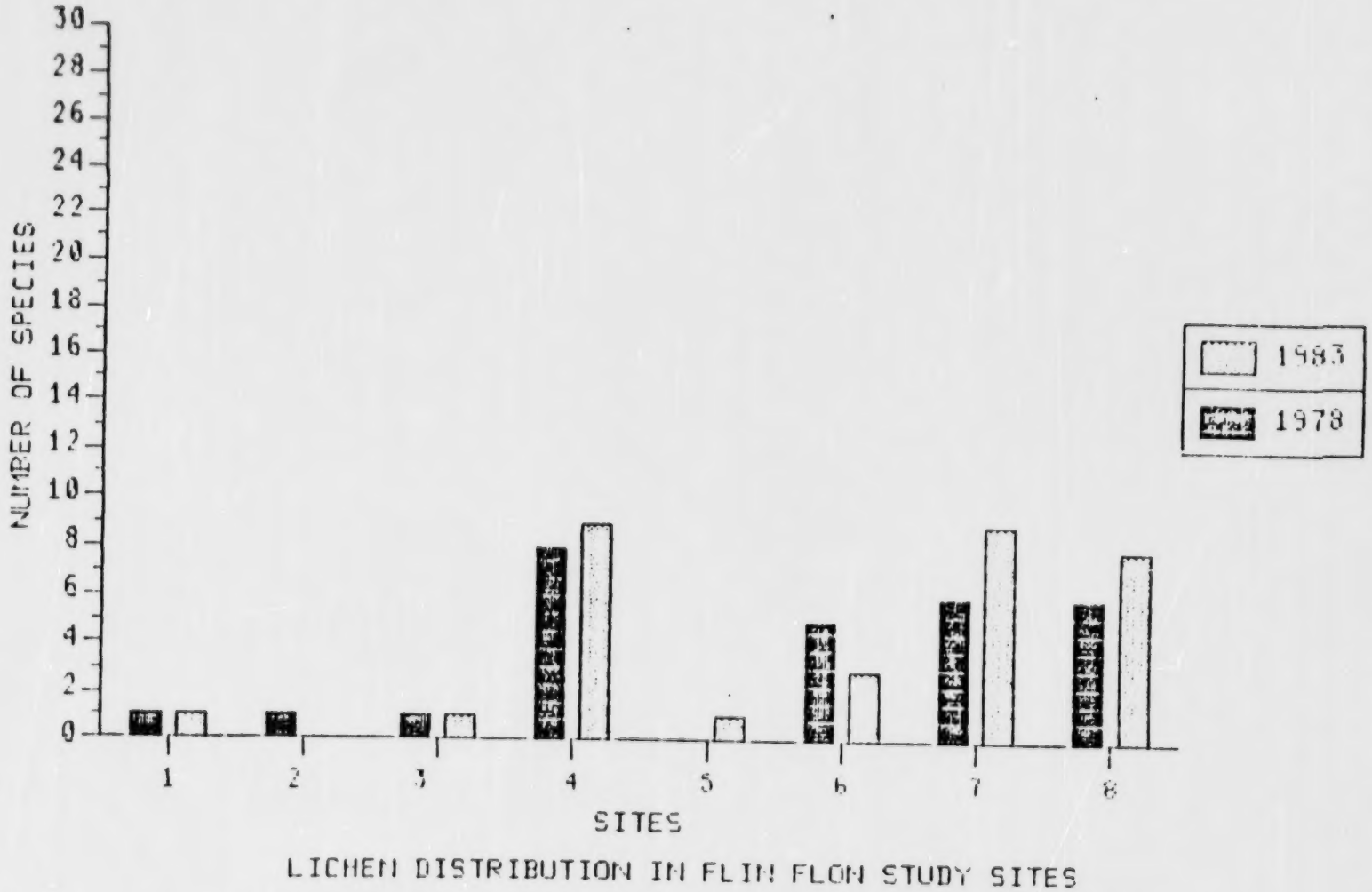
FIGURE 6-3

MAXIMUM ACCEPTABLE LEVEL (MAL) EXCEEDENCES



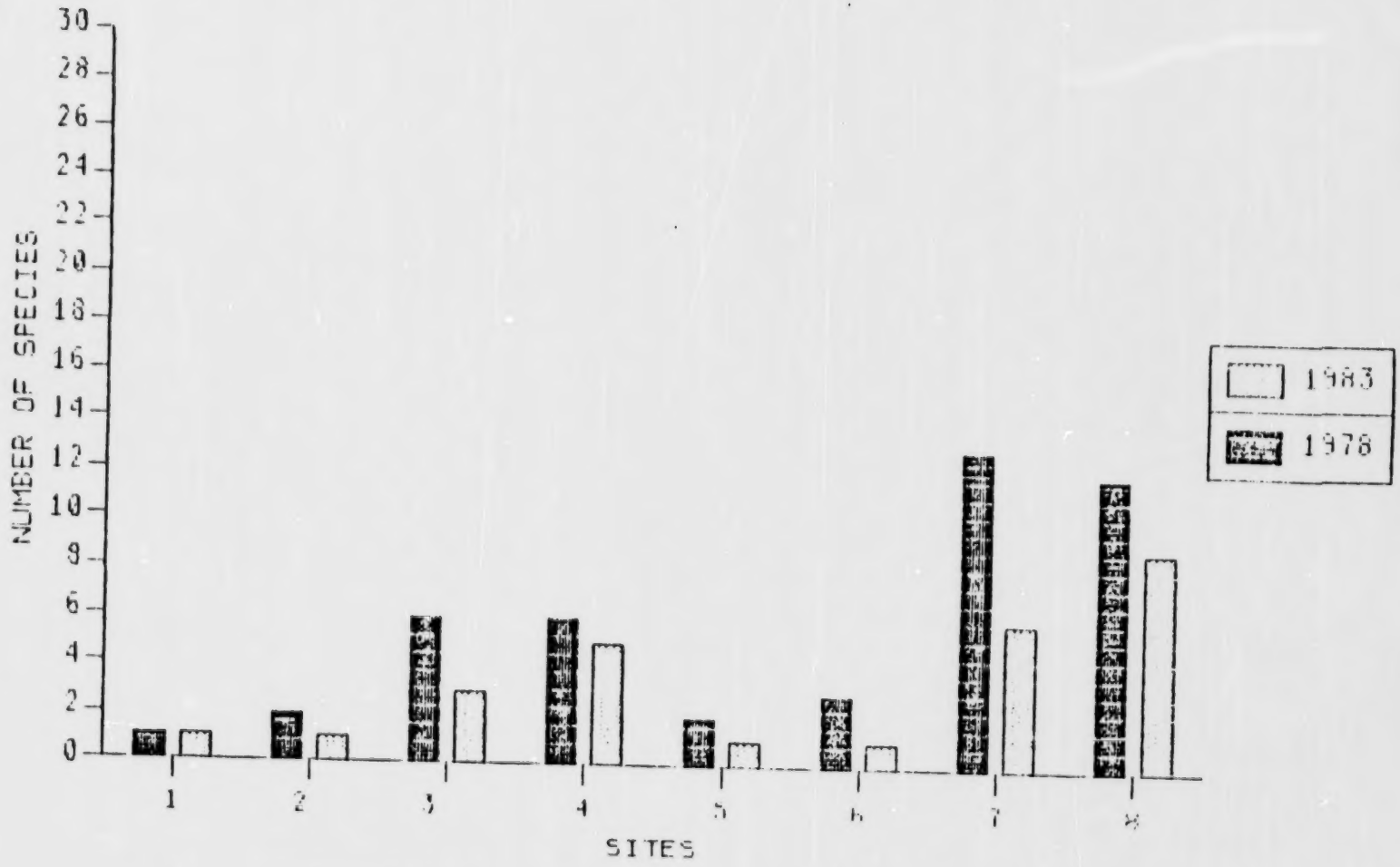
[illegible]

Figure 9-1



Source: A Study of Forest Vegetation in the Flin Flon Area for Atmospheric Emission From the HBM&S Smelter, Wotton, et al, 1983, EMD

Figure 9-2

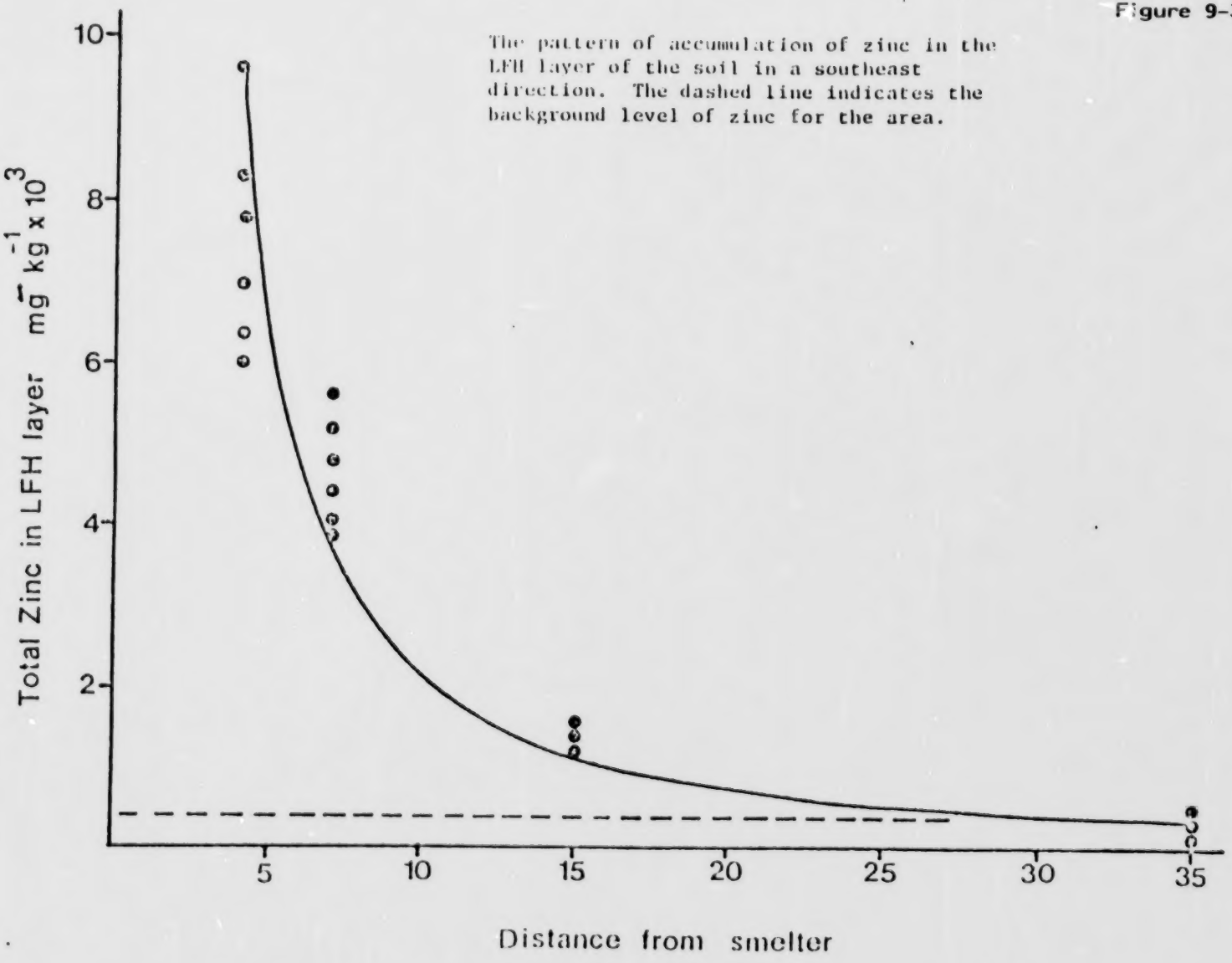


MOSS DISTRIBUTION IN FLIN FLON STUDY SITES

Source: A Study of Forest Vegetation in the Flin Flon Area For Atmospheric Emission from the HBM&S

Figure 9-3

The pattern of accumulation of zinc in the LFH layer of the soil in a southeast direction. The dashed line indicates the background level of zinc for the area.



Source: A Preliminary Report on The Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils, G. Hogan and D. Wotton, 1980.

899VO

AN ORDER OF THE CLEAN ENVIRONMENT COMMISSION

UNDER THE CLEAN ENVIRONMENT ACT

RE: THE CLEAN ENVIRONMENT COMMISSION and HUDSON BAY MINING AND SMELTING CO., LIMITED, Applicant,

WHEREAS pursuant to the provisions of The Clean Environment Act, Hudson Bay Mining and Smelting Co., Limited submitted an application to The Clean Environment Commission to prescribe limits in connection with the operation of a metallurgical complex for the production of copper and zinc located in the NW¼ of Section 6, Township 67, Range 29, West of the Principal Meridian, in the City of Flin Flon, Manitoba;

AND WHEREAS after holding a hearing in Flin Flon on the 10th day of February, 1970, the Commission issued an interim licence on the 1st day of June, 1970, prescribing limits on emissions to the environment from the said operation;

AND WHEREAS on the Applicant submitting an application to the Commission for an ordinary licence on the 5th day of April, 1972, the Commission held a hearing in Flin Flon on the 28th day of August, 1972, and issued Ordinary Licence No. 195, hereinafter referred to as Order No. 195, on the 1st day of September, 1972, for a period of five years;

AND WHEREAS on the Applicant filing an appeal from the said Order No. 195 with the Municipal Board on the 20th day of September, 1972, and on the Board holding a hearing in Flin Flon on the 6th and 7th days of November, 1972, and issuing its Order No. MI 13/72 on the 20th day of December, 1972, the Commission issued a revised Order No. 195 for a seven year period ending the 1st day of September, 1979;

AND WHEREAS on the 10th day of August, 1979, in anticipation of the expiry of Order No. 195, the Applicant filed with the Department an application in connection with the continued operation of the said metallurgical complex;

AND WHEREAS after referral of the application, the Commission held a hearing in Flin Flon on the 20th day of May, 1980, to receive evidence and representations and issued Order No. 899 on the 29th day of September, 1980, prescribing limits on the operation;

AND WHEREAS on the 16th day of October, 1980, Mr. W. W. Fraser, on behalf of Hudson Bay Mining and Smelting Co., Limited, appealed Order No. 899 to the Minister, pursuant to Section 17(1) of The Clean Environment Act;

AND WHEREAS on the 31st day of March, 1981, the Minister directed the Commission to vary Order No. 899 to comply with the intent of Order-in-Council No. 287 dated the 25th day of March, 1981;

IT IS HEREBY ORDERED THAT ORDER NO. 899 BE VARIED TO READ AS FOLLOWS

1. The Applicant shall not discharge from the 825 foot stack of the said operation:

   (a) sulphur dioxide in excess of an average of 885 short tons per day (when averaged over a calendar month);

   (b) on and after the 1st day of September, 1983, total particulate matter in excess of 6 short tons per 24 hour day.

2. On and after the 1st day of January, 1982, the Applicant shall not permit the emission of solid particulate matter from each of the copper smelter dryers of the said operation to exceed a concentration of 0.23 grams per standard cubic metre, calculated at 25 degrees Celsius and 760 millimetres of mercury at the point of emission.

3. On and after the 1st day of January, 1983, the Applicant shall not permit the emission of solid particulate matter from each of the zinc melting furnaces of the said operation to exceed a concentration of 0.23 grams per standard cubic metre, calculated at 25 degrees Celsius and 760 millimetres of mercury at the point of emission.

4. The Applicant shall continue the operation of the ambient sulphur dioxide monitoring program, in a manner and at locations approved by the Environmental Management Division, and report the data on a monthly basis to the Environmental Management Division.

5. The Applicant shall, within thirty days of the first of each month, submit to the Environmental Management Division, a summary of the preceding month's daily sulphur dioxide and particulate matter emissions based on mass balance calculations.

6. The Applicant shall, on an annual basis, conduct a detailed stack sampling program of the 825 foot stack to determine:

6. (a) the quantity of all particulate matter as determined by sampling conducted according to the test code "Standard Reference Methods for Source Testing: Measurement of Emission of Particulates from Stationary Sources" (Report EPS 1-AP-74-1) issued by Environment Canada, or an alternate method approved by the Environmental Management Division;

(b) the identification and quantity of each component of the particulate matter; and

(c) the quantity of sulphur dioxide being emitted to the atmosphere as determined by sampling conducted according to the test code "Standard Reference Methods for Source Testing: Measurement of Emissions of Sulphur Dioxide from Stationary Sources" (Report EPS 1-AP-74-3) issued by Environment Canada, and modified to extend the applicability to the 1.5% sulphur dioxide range.

All sampling shall be conducted prior to October 1st of each year and be observed by an inspector designated by the Environmental Management Division. The emission data shall be submitted to the Environmental Management Division within 60 days of the completion of the testing.

7. The Applicant shall, by the 1st day of January, 1982, conduct and submit to the Environmental Management Division, a study outlining means to eliminate or significantly reduce fugitive emissions of sulphur dioxide and particulate matter from the converter aisle roof monitors and the anode casting roof monitor.

8. The Applicant shall, by the 1st day of September, 1982, conduct and submit to the Environmental Management Division, a study outlining methods and associated costs, including the financial impact on the Flin Flon operation, to ensure that:

(a) the ground level concentration of sulphur dioxide in the Flin Flon, Manitoba, area does not exceed:

(i) 900 micrograms per standard cubic metre for a one hour period;

(ii) 300 micrograms per standard cubic metre for a twenty-four hour period;

(iii) 60 micrograms per standard cubic metre for an annual arithmetic mean;

8. (b) the ground level concentration of sulphur dioxide in the Creighton and Phantom Lake, Saskatchewan, area does not exceed 450 micrograms per standard cubic metre for a one hour period; and

(c) the sulphur dioxide emissions from the 825 foot stack do not exceed 440 short tons per day.

9. On or before the 1st day of January, 1984, this order shall be reviewed by the Commission, pursuant to the provisions of the said Act.

10. Order No. 899, as varied to comply with the intent of Order-in-Council No. 287/81, be and is hereby designated Order No. 899VO.

Order No. 899VO

Dated at the City of Winnipeg
this 10th day of April, 1981.

Chairman,
The Clean Environment Commission.

File: 1095.2

CHAPTER III

OCCUPATIONAL ENVIRONMENT OF HUDSON BAY MINING AND SMELTING

TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHOD	1
WORKER'S EXPOSURE	1
PROCESS DESCRIPTION	2
SURFACE OPERATIONS	4
DISCUSSION OF QUANTITATIVE EXPOSURE	13
JOBS TITLES BY EXPOSURE CATEGORY	16
QUANTITATIVE EXPOSURE TABLES	

INTRODUCTION

The objective of this chapter is to describe the technological process at Hudson Bay Mining and Smelting Co. (HBM&S). Workers occupational jobs titles were grouped into exposure categories and quantitative estimates of exposures were derived for those categories where data was available.

The technological process was described in collaboration with HBM&S. The grouping of job titles into exposure categories was reviewed with the representatives of both the management and the unions of the company. In determining quantitative indices of exposure, industrial hygiene surveys and monitoring by HBM&S, Labour Canada and the Provincial Government were used.

METHOD

Job titles used for this study were those listed in the company's Human Resource Index files. In these files, most tasks performed by workers between 1930 and 1980 were given titles. Additional job titles, encountered while reviewing employment of 645 workers who died between 1952 and 1984, were added to the list. All these job titles were first grouped according to similarity of tasks or working area. For example, all mining duties are grouped in category A. Where possible, each category was divided into one of three sub-categories (1, 2 and 3), reflecting a descreasing degree of exposure within each exposure category.

The grouping of the job titles, was reviewed by representative of both the HBM&S management and the employees to achieve consensus on the proper group placement for each job title. Once grouped, exposure data was matched with each category. This data appears on the tables entitled "Quantative Exposure".

WORKER'S EXPOSURE

Worker exposure was first assessed and recorded by the Provincial Department of Mines in the early 60's. At that time, total dust was measured by a konimeter in parts per cubic centimeter (ppcc). The nature of this method of sampling and measuring makes direct comparisons between the past and present surveys impossible. For this reason, data gathered until mid 1970's was used as a guide rather than a direct estimate of exposure.

The present method of occupational environment monitoring was implemented in mid 70's. Again, the first surveys were taken by the Provincial Department of Mines. Around 1978 HBM&S introduced a more comprehensive monitoring system which is still in operation. In 1983-84 the Federal Department of Labour, which is ultimately responsible for enforcement of the control of worker exposure at HBM&S, conducted the first industrial hygiene survey. The initial survey,

carried out in May/June 1983, repeated in September of the same year and the following January to assess winter/summer exposure differences.

In assessing the worker exposure, 15 contaminants were identified: total dust, zinc, arsenic, cadmium, copper, lead, respirable dust, silica, sulfur dioxide, carbon dioxide, nitrogen dioxide, carbon dioxide, arsine, sulfuric acid, cyanide and asbestos. These appear on the top of the attached "Quantitative Exposure" Tables (1-20). The basis for choosing these parameters was the available data combined with known past exposures. Instances where the potential exposure may exist but no data was available are indicated in the tables by a question mark (?). There are some jobs where exposure would have occurred to contaminants outside the 15 identified in the table. Examples are painters and rubber workers. On the "Quantitive Exposure" table their exposures are designated as "possible solvent exposure". No effort was made to further estimate the type or extent of exposure.

Through taking the arithmetic average of exposure data for each contaminant and applying the formula of Threshold Limit Values (TLV's) for mixtures, an exposure index (IND) of the combined effect of exposure for each category was determined. For this calculation, the 1985-86 ACGIH (American Conference of Government Industrial Hygienists) TLVs were used as the standard exposure limit for each compound or element. By combining jobs into the best fit category, it was possible to estimate an exposure index for those locations where monitoring data was not available. It should be strongly emphasized however, that through this method exposure indices for non-monitored job titles were based on employer's and employee's understanding of similar work exposures.

Caution should be used in interpreting the exposure data and the exposure indices presented in this report. The method of grouping the jobs resulted in broad categorization of jobs which could result in the inclusion of some jobs in categories which may have slightly different exposures. As well, collection of exposure data was limited to those contaminants which were tested and hence, does not include exposure to elements or substances not tested. Even with these limitations, the estimation of exposure is the best available, given the data base. Future studies could, if necessary, further subdivide the groups into more specific job categories.

PROCESS DESCRIPTION

Underground Operations

The production methods used at the Flin Flon operation must be considered when reviewing the exposure of miners. The underground mining of ore in the Flin Flon area has been continuous since the 1930's. The open pit mining operation began in 1931 and was closed in 1944. There has been a considerable change in mining methods, including ventilation, in the recent past. This is particularly

relevant for mining at the Flin Flon site. At the time the mine opened, it relied on electrically powered equipment to transport ore between underground locations. Diesel powered transport was introduced in the mid 1970's.

Drilling of the ore body to prepare for blasting has always been done with a wet bit. In this method, water is forced through the shaft of the drill steel not only cooling the bit but also removing cuttings from around the drilling surface. The wet fines from the drilling operation reduce dust in the air during the drilling process. Once the holes have been drilled, they are prepared for blasting. The blasted ore is then mucked with slushers into bins and hauled by ore trains to the ore pass. At the bottom of the ore pass, ore is loaded into a skip and hoisted to the surface where it is hauled to the crusher to begin processing.

The highest exposure (Category A-1) was assessed for the job titles describing "miners" and those directly involved in the removal of the ore from the mine. The tasks performed by miners at the Flin Flon site include scaling, mucking, drilling, blasting, and other duties listed in Category A-1.

Development miners (rise, drift and exploration) and stope miners could be considered as separate groups. Although the work conducted by these miners is similar, the exposure profile might have been different because of the directional movement of air. Stope miners might have experienced lower exposure because drift miners work in a drift which is a horizontal dead-end tunnel. In a drift, fresh air is brought to within about 50 feet of the working face by vent tubes. The worker is located between the air supply and the source of dust. In the stopes, air is often supplied through a raise and flows past the worker to the working surface and then to the exhaust system which uses the existing tunnels as the conduit. Stope and development miners could not always be separated because the employment records rarely specified which type of mining was conducted.

Underground workers with lower exposures were grouped in category A-2. An example of these workers are timbermen, who construct bulkhead or other underground timber support structures. Within this group there is a sub-category of workers, for example, blasters, drillers and slushers, who where until 1944 employed in the open pit mine.

Category A-3 includes those mine workers whose duties result in lower exposure to dust and diesel/blasting fumes than category A-1 or A-2: surface workers of the mine department such as hoistmen, cooks, watchmen and others who work in areas where little dust is created or where the worker was at all times isolated to minimize the exposure.

SURFACE OPERATIONS

Crusher

The crushing plant represents the first stage in the surface operation at the Flin Flon smelter. The crushing process itself involves feeding large pieces of rock into the top end of a crusher with a shape of a cone. A gyrating pestle crushes the rock against the sides of the cone walls thereby mechanically breaking the rock as it passes down the taper. The product of this gyrator crusher is dropped onto a conveyor and transferred to the Symons Crusher. From here it is fed through the Tyrocks screen. Rock which passes through the 2 cm Tyrock screen is conveyed to surge storage bins for storage before being sent to the mill. Over sized rock is returned to the feed end of the Symons crusher.

Occupations in the crusher area are directed toward the maintenance of the system and the control of product flow. In addition to the conveyor attendant with responsibility to remove wooden debris from the conveyor belt, job descriptions include crusher operators, utility operators and their assistants. Crusher operators are directly responsible for controlling the product flow while utility operators assist the crusher operators, perform routine maintenance on the equipment, and clean up the area.

Revisions to the system had increased the original capacity of the crushing plant from 3000 tons/day to 8000 tons/day by 1977. However, this volume has since been revised downward as crushing processes were brought on line in the outlaying mines. Presently, the primary source of ore crushed at the Flin Flon crushing plant comes from the South Main, Trout Lake, Centennial, and Spruce Point Mines. Current volumes represent about 3800 tons/day.

A review of results for the total dust sampling results showed that the conveyor attendant, Tyrock operator, and utility operators had the highest average exposure. The highest respirable dust exposures were found for the Tyrock and utility workers. Silica levels exceeded the Threshold Limit Values (TLVs) (Table 2).

Two modifications reduced the dust levels in the crusher plant. The first one (about 1976) was the introduction of a dust collecting cyclone servicing the gyrator crusher and the second (about 1977) was the installation of two fans which feed into a baghouse servicing the general area of the plant.

Fine Ore Bins

After the rock has passed through the Tyrock screens, it is deposited onto a conveyor and taken to the fine ore bins. These surge bins are loaded by a tripper car and emptied through a gate at the bottom onto a conveyor to be transported to the mill.

Occupations in this area are defined as tripper car operators and fine ore bin attendants. In this area, the primary concern is the exposure to total dust and primarily respirable dust.

Mill and Flotation

Water is added as the ore enters the rod mill and the slurry is pumped from the rod mill and cycloned to separate small size particles. The larger fractions are reground in the ball mill before joining the small fractions to be directed to flotation. In flotation, reagents are added causing a specific metal to be absorbed onto the outer surface of air bubbles. Air bubbles rise to the surface of the solution where they are skimmed off. This concentrate is pumped to thickeners. In subsequent flotation new reagents are added to the slurry to separate the next desired metal. Cross-contamination of metals is removed in subsequent processes.

After flotation the concentrate is sent to thickeners where some liquid is removed by drawing from the bottom of the thickeners. The slurry is then pumped to the filters for further removal of liquid waste. The resulting cake is transported by conveyor to the bedding bins where it is stored until being fed into the roasters.

Primary occupations in this area are the mill and flotation operators, and their assistants. In addition there are reagent attendants, whose duty it is to add the reagents, and utility persons responsible for the ongoing maintenance of the equipment.

Worker exposure to dust was estimated for the rod and ball mill attendants, and the mill utility operators or labourers. These estimates are summarized in Table 3. There was no data on the exposure of workers to the reagents added to the slurry in the flotation process.

The highest total dust exposure was experienced by the rod mill operator followed by the ball mill operator. Exposure estimates are not available for the mill labourers who spend time in the general area of the mill. Data is also not available for workers employed in the area of the thickeners and filters. Since the concentrate enters the area as a slurry and is sent out as a damp cake, little if any exposure to dust would be expected.

Until the mid 1970s, an enclosed system was used for cyanide treatment of waste tailings to recover gold and silver. In 1974, the rod mill section was added. Over the years there were no other notable changes in the milling, flotation, thickening, and filtration processes which would alter worker exposure. However, as pointed out earlier, the nature of the process would usually not result in high dust levels.

Bedding Bins

Copper concentrate is dumped from the filters into one of five bedding bins by a tripper car which is operated by the tripperman. The tripper car is first moved to the desired bin. Concentrate is brought to the car by a conveyor and deflector gates on the car divert the concentrate allowing it to fall into the bin. The amount of dust in the air depends on the distance from which the concentrate falls, the source of the concentrate, and the amount of moisture in the product. Once in the bins, concentrate is stored until it is scooped out by a clam crane and dumped into a hopper which feeds the conveyor for transfer either directly to the roasters or back to the dryers. If the concentrate is sent to the dryers, it is first blended with zinc sulfide residue. Certain concentrates purchased from other producers are unloaded by bucket loaders from rail cars and directed to the bedding bins or outside storage. The water content of these concentrates are usually lower and consequently they generate more dust than concentrates originating from the Flin Flon mine.

Primary jobs in the bedding bin area are the transfer (tripper) men who operate the tripper car, the conveyor and the deflector gates; and the bedding bins craneman who operates the overhead crane which loads the concentrate from the bedding bins onto the conveyor for transfer to the roasters.

Worker exposure to total dust is higher for the craneman and conveyorman than for the tripperman. There is however a marked difference in the composition of the dust from that in the previous areas. For the bedding bins, analyses indicate a minimum of a 10 fold increase in the concentration of zinc, arsenic, copper, and lead in air. Cadmium, which was below the detectable level in all areas to this point in the process, is present with an average of .003 mg/m^3.

Copper Process

The copper smelter has been in operation since 1931. Originally it consisted of 3 Nichols-Hershoff roasters, a coal fired reverberatory furnace, two Pierce-Smith convertors, a 4-unit electrostatic precipitator, and a blister copper casting wheel. In 1932-1937, the reverb silica brick sprung arch was changed to magnesite brick. A fourth roaster was added in 1936 and a third converter in 1940. A fifth roaster was added in 1942, and in 1951 the front end of the reverb was widened to facilitate increases in production. In 1951, the slag was diverted through the fuming furnace to recover zinc fume from copper reverb slag. A baghouse was added in 1957 to collect reverb and converter dust passing through the cottrells. The coal fired process was converted to oil in the drying and reverb process in 1971. A 250 meter stack, anode refining, and casting facilities along with a reverb waste heat recovery boiler and a new electrostatic precipitator were installed in 1974, and mechanical converter punchers were installed in 1975.

Copper Roasters

Concentrate arrives at the roasters on conveyors and is deposited into bins on top of the roasters by a tripper car. These bins feed the roasters on the feed floor by a ratchet-operated feeder belt. Coal fed burners located on the eighth hearth assist in combustion of the sulfides. This removes about 50 percent of the sulfur content of the concentrate. Roasted concentrate (calcine) is collected in steel hoppers from which it is dumped into a calcine train and transported to the reverberatory furnace.

Occupations in the copper roasting area include the tripper, feed floor, roaster operator, and operator helpers. A summary of worker exposure indicated a different exposure profile for each location. Although the operator helpers were exposed to a higher total and respirable dust level, their average sulfur dioxide exposure was one third of that for the tripperman (see Table 7). Similar results were noted when reviewing exposure to concentrations of contaminants. The feeder man, who is located one floor below the tripper car, experiences an average exposure between that of the operator and the tripperman. As the process involves heating the ore to drive off the sulfur gases and fumes rise up through the roaster. The irregularity of combustion combined with the reliance on natural stack-draft for air flow occasionally creates positive pressure in the roaster allowing fumes to escape from the roasters. This could in part explain the increase in fumes and sulfur dioxide levels as sampling points increase in elevation to the area of the tripperman. Conversely, the higher dust levels experienced by the roaster operators could be a result of the presence of readily airborne calcine which could be intrained within escaping gases.

Reverberatory (Reverb) Furnace

Once through the roaster, the calcine is dumped onto the train for transportation to the reverb furnace. The train is operated by a brakeman and an engineer. At the calcine bins, the cars are moved under the bins. The brakeman opens a chute and the hot calcine falls into the car; an exhaust system was installed to control the dust generated when the cars are being filled.

Once the cars are filled, the train is moved to the reverb furnace. Here, gates are opened and the calcine is dumped from the bottom of the car into the hoppers above the furnace sides near the front of the furnace. In addition to calcine, roaster and converter flue dust, precipitator dust, and crushed reverts are fed into the reverberatory furnace. Presently four oil burners, situated in the front wall, heat the air to maintain a temperature of 1365-1535 degrees centigrade in the furnace. This temperature promotes the formation of iron-silica slag and copper-iron sulphide matte which are separated by gravity. Copper containing matte is tapped from the furnace and sent to the

converters.

Furnace side walls are 24 in. magnesite bricks, while the arch is 31 ft. of 18 in., 24 ft. of 15 in., and 46 ft. of 12 in. magnesite brick suspended from an iron framework. The brick arch is repaired without disturbing the continued operation of the furnace; full replacement of the arch and side walls is done when the smelter is completely shut down.

Slag is tapped into 18 ft. rail mounted ladles underneath the brick end of the furnace while matte is tapped from two holes on one sidewall halfway down the furnace. Exhaust gases are drawn through uptakes at the brick end of the furnace at a rate of 60,000 cfm. Heat is reclaimed by two heat recovery boilers. Gasses are then passed through the electrostatic precipitator and baghouse before being emitted through the main stack.

Exposure levels for the brakeman and the locomotive engineer are the highest of all occupations in the smelter. Because of these high levels, these employees have worn full face respirators since the mid 1970's. Prior to this, cloth masks were used by the employees for personal protection. In addition to the exposure incurred when loading calcine, a second exposure occurs when unloading the cars at the reverb. Here the exposure to dust fumes and sulphur dioxide would be a reflection of the levels above the reverb furnace.

At the reverb, primary job descriptions include furnace feeders and operators, slag and matte tappers, utility operators, and brick layers. Worker exposure to dust and fumes varies considerably from day to day as well as from location to location. Slight shifts in the external environment such as daily wind velocity and direction or internal conditions such as the feed or exhaust air rate, or even furnace temperature, could change the profile of worker exposure. These fluctuations in conditions were reflected in data on exposure. As an example, the total dust exposure for the furnace feeder ranged from 1.8 mg/m^3 to 16.5 mg/m^3.

For the bricklayers, whose job includes changing the bricks on the furnace roof, heat exposure has been documented as high but is not presented in this report. The intensity of heat in the area where they work would damage standard monitoring equipment. To assess the exposure of the bricklayers, the best estimates are those collected on the feed floor. The range of exposure is considerable. Another factor which would affect the exposure of bricklayers is the practice of cooling down the furnace when repairing the roof.

Slag and matte tappers experienced a lower average exposure than the feeders. However, their exposure, like that of the feeders, is dependent on furnace operating conditions.

Fuming Plant

In the early years, slag from the reverb furnace was taken directly to waste. The construction of the fuming plant in 1952 redirected the slag through the furnaces for the purpose of metal recovery before it was disposed as waste.

Ladles are conveyed from the reverb by rail. On arrival at the fuming plant, they are lifted by the crane and emptied either into an electric arch holding furnace or directly into the fuming furnace. Once in the fuming furnace, pulverized coal is forced into the hot slag reducing and vapourizing zinc, lead and other reclaimable metals. The off-gas stream is contacted with air to oxidize the vapourized metal to form fine particulate; the stream then passes through a heat recovery boiler before it is sent to a baghouse where the particulate is filtered out. Gasses are then vented into the general atmosphere through the short exhaust stacks. After about two hours, the furnace is shut down and the slag is tapped into ladles and transported for disposal. Precipitate from the baghouse is sent to the oxide roaster for further treatment.

Primary job descriptions at the fuming plant include swampers, tappers, operators, and cranemen. Exposures ranged from 1 mg/m^3 to 5 mg/m^3 for total dust. Although at the time of sampling the highest exposure was found for the area of operator helper, the samples were area samples and hence more indicative of the exposure in that location than for that occupation. When comparing the metal composition of the total dust in the fuming plant and in the reverb furnace area, the concentration of zinc was higher in the fuming plant, while the concentration of copper was higher in the reverb furnace area.

Converter and Anode Casting

Matte which is tapped from the reverb furnace is transferred by ladle to one of three converters. The usual practice is to charge each converter with four, 150-ft^3 full ladles and add flux as required. Cycles of matte addition and slag removal are continuing until the converter contains about 75 tons of "white metal". The charge is then air blown to obtain "blister" copper (98.5% Cu). Slag is skimmed off and returned to the reverb. After blowing off to further reduce the sulfur content, the "blister" copper is transferred to an oil fired anode furnace for casting and shipment of anode copper.

Worker exposure data collected in 1980-81 indicated that the highest total dust exposure was estimated for the converter puncher (average total dust level of 5.9 mg/m^3) and the lowest level for the craneman (.35 mg/m^3 dust). The exposure to sulfur dioxide for the two jobs was reversed (0.9 and 2.1 ppm respectively). A similar reversal was noted in the exposure to SiO_2. The high exposures to SiO_2 occurs because flux, which is the source of this contaminant, is added to the

converters when they are turned out from the capture hoods. This positioning of the converter combined with the high temperature of the converter bath results in substantial volumes of off-gases and dust when the flux is added. The location of the cranes with respect to the path of exhausting air could account for the elevated levels experienced by the cranemen.

There is no information available on exposures of workers in the anode casting area. Although there has been from time to time some concern expressed with respect to gases evolved when the furnaces are being blown before casting, there is no documentation of the nature of these gases.

Zinc Process

Zinc concentrate from the mill is roasted to reduce the sulfur content. It is then leached through a liquid process and electroplated out in the tankhouse. The electroplated zinc sheets are melted in the casting plant and cast into ingots for shipment. Cadmium is separated from the zinc and processed on a separate cadmium line.

Roasters

Zinc concentrate is sent from the bedding bins by conveyor to the roaster tripper car. The tripper car is first moved to the appropriate hopper and the concentrate is then deflected into the hopper. On a floor below, the concentrate is fed from the hopper by a variable speed feeder into the periphery of an open dryer hearth. Each roaster has 7 fire-hearths with air cooled cast iron alloy arms supporting 9 or 10 alloy-steel rabbles rotating at 17 revolutions per hour. After passing over alternately in and out-drop hearths, the calcine is discharged to a hammer screen to separate oversize for reduction through a 6 by 4 in. dry grind ball mill. The mill grindings along with the off-gas electrostatic precipitator catches are conveyed to the roaster for retreatment. Calcine screen undersize is collected from each roaster by rotary conveyor and transported either to a 1000 ton surge bin or to the leaching plant for further processing.

Occupations in the zinc roaster area include the tripperman, feederman, roaster operator and helper, and ball mill attendant. As in other areas, there is a considerable fluctuation in exposure levels. For example, of the five samples taken on the same day in different locations in the same work area, the HBM&S estimates of total dust ranged from 1.11 to 28.93 mg/m^3. When averaging HBM&S data on the basis of worker exposure, the highest average exposure for total dust was the tripperman with (13.4 mg/m^3), followed by the ball mill attendant (7.7 mg/m^3), the gearfloor (5.4 mg/m^3), the feeder man (3.1 mg/m^3) and the operators (4.7 mg/m^3). Measurement carried out by Labour Canada confirmed this pattern of exposure.

In addition to the total dust data there is some information on sulfur

dioxide levels. This data which appears on table (7) ranged from a high of 20.6 to a low of 4.1 ppm.

In the zinc roaster area and in the copper roaster area, considerable attention must be given to the composition of the total dust exposure. There were instances when an individual constituent of the total dust exceeded TLV although the total dust level was low. Considerable fluctuations of the exposure estimates occur as a result of changes in the composition of the concentrate, feed rates, roaster draft rates, and even external atmospheric conditions such as wind direction and velocity.

Leaching Plant

The leaching plant receives zinc calcine from the roasters. Zinc oxide calcine is treated by a solution comprised of oxide neutral thickener overflow, sulphide acid thickener overflow, and return tankhouse acid. The zinc is leached in an acid media (pH 4.7-5.2) in 8 series-connected, air-agitated, wood-staved 30 x 10 ft. diameter pachuca tanks. Thickeners are used to separate liquid from the solution. The undissolved calcine as (solid sulfide residue) is directed to the smelter for treatment. Oxidation and hydrolysis promote the precipitation of impurities. The liquid is purified in a number of steps. Filtered and clarified electrolyte is pumped to the tankhouse for zinc electroplating. Cadmium is precipitated out, filtered, electroplated, and eventually cast into balls and slabs for shipment, while copper is transferred to the copper smelter for processing.

Occupations in the leaching plant have remained relatively constant over the years. Because the process material is a slurry at this point, exposure to dust has not been a concern. Surveys taken as far back as 1975 by the Provincial Department of Mines report an average dust level of 59 particulate per cubic centimeter (ppcc) which would be considered low. More recent surveys in 1981 conducted by the company indicated an average of 2.2 mg/m^3 in the oxide secondary leach and 2.4 mg/m^3 total dust in the oxide neutral leach operator areas.

There are no estimates of exposure of workers to reagents which are added to the process to enhance precipitation. Similarly, estimates of exposure to acid fumes are not known.

Tank House

The electrolytic tankhouse uses 1180 cells in a double cascade of 10 cells each. Two rows of cells are fed normal acid discharge from an adjacent double cascade to produce "high acid" for other processes. Each of the 340 gallon fiberglass cells contains 18 5/16 in. silver-lead alloy anodes and 17 11/64 in. high-purity aluminum cathodes with nickel plated copper contacts in the header bars. The electrolyte is cycled through the first 9 cells and zinc is plated on

the cathode. Spent solution from the 10th cell is returned to the leaching plant. Plated zinc is manually stripped every 24 hours, weighed, and stored for processing in the casting plant.

The purpose of jobs in the tankhouse is the maintenance of the system or the stripping operation. The tankhouse is an open space building. In 1977, a forced air makeup system was introduced which supplies fresh air to the bottom end of the building. This was in addition to the exhaust fans which are located on the roof at the top end of the building. Air samples, taken when the system was in operation in 1983-84, yielded an average sulfuric acid mist in air of .56 and 1.5 mg/m^3. One sample taken in 1969 by the Provincial Department of Mines reported a level of 1.5 mg/m^3. The location of the sample taken in 1969 is not known. Since in 1983-84 (Table 5) samples were taken at the bottom end and at the middle of the tankhouse, they represent a cross section of worker exposure. Review of the data confirmed that a gradient of increasing exposure is experienced as workers move up the tankhouse. The lowest exposure occurrs at the bottom end where the zinc is stripped from the cathodes.

Worker protection has been a concern in this area. Presently, only some workers wear approved personal respiratory protection. The remainder wear a makeshift wire frame wrapped in gauze, a device traditionally used because rubber face masks result in an acid rash at the mask/skin interface.

Zinc Casting

Prior to 1982 zinc was melted in two reverberatory-type brick furnaces with a combined capacity of 250 tons per day. The furnaces were charged through openings in the center of the furnace arch. Sheets of zinc were either thrown in by hand or dumped with a forklift. Firing was by the use of 4 Bunker -C- Haucks 782 burners. Dross was pulled off dry, milled and reprocessed for zinc reclamation. In addition to the two reverberatory furnaces, the refined zinc could be transferred to two 45 ton and one 5 ton alloy melting pots. Casting was done on two Shepperd slab casting racks or on various block casting lines.

In 1982, when a new casting plant became operational, the reverb-type furnaces were replaced by an electric induction furnace. This furnace is charged by a forklift which places zinc sheets into an automatic feeder. The feed rate is controlled by the furnace operator. Dross is pulled off under local ventilation and is processed for metal recovery. Zinc is pumped into a holding post and directed to an automatic ingot caster. A skimmer removes the surface oxide layer and the caster then assembles the ingots in bundles for shipment. Scrap zinc is either returned to the casting furnace or converted to atomized zinc dust.

Data prior to the introduction of the new zinc plant in 1982 was limited to the exposure of the dross plant operator. This data was taken in 1980 and 1981. Ten samples for dust were taken in both cases, yielding an average exposure of 14.5 and 16.8 mg/m^3 respectively. Samples taken after the introduction of the new plant are more complete and indicate a much lower exposure. The high estimate in the 1983 survey was 6.4 mg/m^3 for the dross plant operator by HBM&S, and a low of 0.3 mg/m^3 for the caster taken by Labour Canada (Table 6). As reported by the Manitoba Department of Mines, results taken in 1980/81 are not an exact reflection of continued exposure but may rather represent worst-case conditions.

Lead Casting

As stated earlier, the anodes in the plating operation are made from a lead and silver alloy cast by HBM&S. Lead ingots and lead reclaimed from spent anodes are mixed with silver in the lead room casting furnace. Average dust levels from surveys in the lead casting room taken since 1980 range from 0.4 mg/m^3 to 7.9 mg/m^3 (Table 6). The worker exposure to individual metals differs from that in other areas. Results of industrial hygiene indicate higher lead content in the dust with frequent absence of detectable levels of arsenic or cadmium. These results are consistent with the operation at this stage in the process.

Cadmium Plating and Casting

In the cadmium process, electrolyte is pumped through plating tanks. Cadmium is plated on the cathode and the overflow is returned to acid thickeners for recycling. Sheets of cadmium are stripped from the cathode and melted in a small furnace to be cast into balls or pencils for shipment.

The stripping and casting operations occur in two separate areas. Some exposure estimates have been collected (which would reflect conditions in the general area) since 1980. The summary of this data (Table 20) indicates that, although the total dust exposure for the stripper is lower (0.53 mg/m^3) than for the caster (1.3 mg/m^3), the cadmium exposure for the stripper (0.044 mg/m^3) is twice as high as for the caster. One of two possible explanations suggests that fumes from the casting area migrate into the stripping area. The other suggests that cadmium was released as cadmium sulphate from the electrolytic in the plating area.

DISCUSSION OF QUANTITATIVE EXPOSURE

Tables 1 to 20 entitled "Quantitative Exposure" display estimates of worker exposure for each area-job grouping. These estimates are averages of estimates of exposures measured by HBM&S, and the Federal and Provincial Governments. Each table contains data for one of 20

major area-job groupings. Each table has space provided for estimates of exposure to 15 different contaminants which may at one time have been tested for, or have been identified as possible exposures. The final column "IND" is the calculated Threshold Limit Value (TLV) for Mixtures, calculated according to the "Threshold Limit Values and Biological Exposure Indices for 1985-86" (ACGIH).

A number in the table indicates an estimated exposure to a contaminant. It was obtained in the following way. First, all exposure data available for a specific grouping and category (eg. group A, category 1) were identified. This data was then averaged for each contaminant. The number representing the estimated exposure to a contaminant is a ratio of the estimated exposure to the TLV for that contaminant. For example, in category A-1 (Table 1) total dust has a value of .152. This number means that the estimated exposure of A-1 is 15.2 percent of the TLV for total dust. In the final step the "IND" representing the exposure to mixtures was estimated. According to the standard method for calculating TLV for mixture, a category of workers is overexposed if "IND" exceeds value 1. The presence of a question mark (?) denotes the absence of any data, although exposure to that contaminant would be expected for the respective grouping. A blank indicates that there was no evidence to suggest a possibility of exposure to the contaminant.

The total number of samples from which estimates of exposure were reviewed ranged from a high of 243 for the category H-1 to a low of 10 for the category T-1. The variation of the number of samples varied considerably from category to category. Detailed information is available on request.

The value for the combined exposure grouped from a low of .194 in category F-2 to high of 8.841 in category G-1. For many categories, IND could not be calculated because of missing data. For categories for which "IND" was calculated, IND could be used to rank the exposure categories. Such reviewing suggest high exposures for workers in certain areas of the plant.

Table 10-1 contains data on exposure of workers in the underground mining operation. While the information was available for carbon monoxide, carbon dioxide, nitrogen oxide, and total dust, there was limited data available on exposure to silica and respirable dust.

In forming the job categories the greater exposure was asigned to category 1 with categories 2 and 3 having less exposure respectively. When reviewing the data as a rule the accumulated exposures in category 1 was higher than 2 which was higher than 3. This evidence confirms that the placing of jobs into categories, which was completed before the data was tabulated, is relatively accurate. The exception was category T because of the limited number of samples (10). However, there are several categories where all existing data confirm an excessive exposure with given jobs.

The data does confirm a different exposure profile in each category. This difference in exposure should provide useful information when comparing jobs with mortality or morbidity data.

Comparison of job categories within each group is reflective of exposure differences. For this reason it would be fair to compare category 1 to categories 2 and 3 where these categories exist. It is not however, reasonable to make direct comparison between groups. As an example, group A category 1 miners, should not be compared with, group G category 1 because of different exposure profiles.

Missing data is an outstanding problem. There is no way of determining past exposures. In the absence of data, evidence for potential exposures must be based upon the possible contaminants associated with that part of the process. Even with the existing data a limiting factor is the restriction of potential exposures to those substances tested for and listed in the "Quantitative Exposure" tables.

JOBS TITLES BY EXPOSURE CATEGORY

A - Department 10

Underground:

Category 1

Skiptender 1st
Skiptender 2nd
Lead Miner
Development Miner
Scooptram Drift Leader
Underground Crusher Operator
Motorman
Bulldozer
Brakeman
Slusherman
Raise Miner
Shaftman
Shaftman
Miner
Blast-Driller
Machine Helper
Blast-Hole driller Helper
Mucker
High Raise Blaster
Jumbo Operator
L H D Operator
Locomotive Engineer 1st
Miner Apprentices
Blast-Hole Boss
Bull Cook
Drill Sharpener
High Raise Miner
High Rigger
Miner Laborer
Shaft Miner
Drill Sharpener Operator
Drill Shop Helper
Mucker Boss
Drill Steel Shop Helper
Drill Shop Helper
Driller's Helper
Electrical Maintenance

Head Rigger
Driller
Blasting Boss

Category 2

Drill Steel Shop Forman Temp. Use.
Bit Brazer
Steel Sharpener 1st
Steel Sharpener 2nd
Electrical Sub-Foreman
Electrician 1st
Electrician 2nd
Electrician 3rd
Electrician Helper
Lead Industrial Mechanic
Bullgang Foremen
Repair Foreman
Industrial Mechanic 1st
Repairman 2nd
Repairman 3rd
Repair helper
Handyman
Oiler 1st
Pipeman
Pumpman
Oiler 2nd
Trackman 1st
Trackman 2nd
Machine Doctor
Cagetender 1st
Cagetender 2nd
Deckman 1st
Deckman 2nd
Timber Jigger Boss
Shift Boss
Powderman
Timberman 2nd
Timberman 1st
Shaft Inspector
Bullgang Boss
Scaler
Sanitary Man
Industrial Mech. Appr.
Electrical Apprentice
Labour
Mine Survey Helper
Mine Survey/Eq Tech/Surv Help
Mine Surv/EQ Techn/Vent Techn/Planner
Contract C/ord/Min Sur/Safety Inspector
Mine Eng/Planners/Surv/Techns/Analy.

Mine Safety Boss
Sh. Sup. Eng 2/Min Sch. and Appr. Inst.
Timber Repr/Mine/Maint Shift Boss
Mine/Mine Service/Mine Repr. 4-Men
Mine Gen. Foreman Ungd. Suptdnt
Mine Surv/Eq Techn/Vent Techn/Planner
Mine Planner/Eng./ and Rock Mechanic
Air Engineer
Air Engineer M. Cat. A.
Drill Operator
Drill Operator
Electrical Turn Operator
Higher Foreman
Jigger 1st
Mine Helper
Mine Safety Foreman
M.S. Handyman
Underground Oiler
Shaft Timberman
Trimmer
Pitman
Jigger Boss
Ind Mech Foreman (Mech)
Improver
Level Boss

Category 3

Electrician Lineman
Hoistman 1st
Hoistman 2nd
Surface Laborer
Timekeeper
Crane Operator
Engineer 1st Class
Engineer 2nd Class
Engineer 3rd Class
Engineer 4th Class
Shovel Operator 1st
Heavy Truck Driver
Medium Truck Driver
Light Truck Driver
Bulldozer Operator 1st
Bulldozer Operator 2nd
Garage Sub-Foreman
Lead Gas Mechanic
Gas Mechanic 1st
Gas Mechanic 2nd
Lead Machinist

Machinist
Lead Steamfitter and Plumber
Steamfitter and Plumber
Lead Carpenter
Carpenter 1st
Locomotive Engineer 1st
Brakeman 1st
Straw Boss/Gardener/Relief Cod
Checker 1st
Cookee
Waitress Opr 2nd
Waitress Opr 1st and Maid 1st
Asst. Cont. CL/Mine Timekpr/Utility
Relief Cook
First Cook
Contract Clerk
First Aid Instructor
Mine EQ Techn/Planner/Br Tech/Surveyer
Mine Planner/Equ Eng/Vent Techn/Mech.
Mine Planner/Equ Eng./Vent Techn/Analy
Mine Planner/Eng./and Rock Mechanic
Sr. Mine Equipment Eng. Sl
Mine Watchman
Cafetra-Asst. Cafeteria Manager
Chief Hostman/Sl Sup. Eng. 3rd
Suf/Sl Whse/Sl Asst. Whse 4-Men
Assistant Surface Training Supervisor
Assistant Wrehouse Manager
Boom Truck Helper
Churn Drill Operator
Electrical Locomotive Driver
Electrical Locomotive Engineer
Heavy Truck Operator
Helper
Helper M/S--Janitor
Light Truck Operator
Mine Foreman
Mine Safety Co-ordinator
Mine Shift Boss
Mine Surface Laboer
Open Pit Shift Boss
Operator & Pipeline Patrolman
Steward
Stope Engineer or Slope Engineer
Storekeeper
Train Repair Foreman
Open Pit Miner
Open Pit Brakeman
Open Pit Labourer
Engineer Helper 1st
Churn Driller
Grizzlyman

Slop Assayer
Dinkey Driver
Engineer
Loco Engineer 3rd
Churn Drill Helper
Cookee (Smelter)
Cook 3rd
Night Cook
Baker
Night Foreman
Shift Boss
Asst Surface Labour Foreman

B - <u>Department 20</u>

Crusher:

Category 1

Repair Sub-Foreman
Repair 1st (Crusher Operator 1st)
Repair 2nd (Crusher Operator 2nd)
Repair 3rd
Repair Helper
Tripper *
Mill and Crusher Shift Bosses
Crusher Foreman
Crusher Shift Foreman
Crusher Shift
Crusher Operator 1st
Rock Picker
Crusher Helper
Crusher Swing Boss

C - Mills:

Category 1

Special Flotation Operator
Mill Shift Boss (Temp. Use only)
Mill Operator 1st
Mill Operator 2nd
Mill Operator
Mill Helper
Laborer
Mill Labour Boss
Brake Mill Operator 1st
Mill Craneman
Mill Roustabout
Ball Mill Operator 1st
Ball Plant Operator

Ball Mill Operator 2nd
Mill Shift Foreman
Mill Repair Foreman
Assistant Cyanide Foreman

Category 2

Mill Clerk
Milland Mill Material Technician
Mill Metailurgest
Mill Technical Foreman
Mill General Foreman
Mill Foreman
Trackscale Clerk
Sand Helper
Ball Plant Foreman
Relief Crusher Foreman Mill

Department 30

Zinc Processing

D - Leaching:

Category 1

Leaching Shift Boss (Temp. Use)
Head Operator
Operator 1st
Operator 2nd
Laborer
Special Swing Operator
Special Operator (Shriver Press)
Tailor 1st
Tailor 2nd
Tailor 3rd
Copper Sulphate R. Man
Fliter Helper
Leach and Cad Shift Boss
Leach Tester
Leaching Plant Helper
Leaching Plant Shift Boss
Leaching Tester
Leaching Shift Boss (Temp Use)
Zinc Lech Superintendent

Zinc Leching Helper
Leaching Operator
Classifier Operator
Head Flotation Operator
Cyanide Operator 2nd
Classifier Man
Cyanide Operator 3rd
Thickener Operator
Filter Operator
Flotation Helper (Special Floto PR)
Flotation Shifter
Cyanide Helper
Flotation Operator 1st
Cyanide Operator 1st
Leaching Helper
Flotation Operator 2nd
Finish Carpenter
Leaching Opr ZN Plt
Copper Sulphate Leachman (Zincp Lt)
Classified Operator
Cyanide Foreman

E - Tankhouse:

Category 1

Stripper Loader Bottom Tank Strip
(High Acid Man)
Stripper
Stripper (Convert)
Stripper (Gang)

Category 2

Tankhouse Shift Boss (Temp. Use)
Special Operator (Testers)
Tankhouse Boss
Tankhouse General Foreman
Tankhouse Operator
Tankhouse Stripper
Tankhouseman Helper
Tank Foreman
Tank Boss
Tankhouseman
Tankhouse Helper

F - Zinc Casting:

Category 1

Operator 1st
Operator 2nd

Head Operator
Spec. Opr. (2nd Charges and Casters)
Head Operator
Operator 1st
Operator 2nd
Head Operator
Cast Plant Operator
Caster--Zinc
Casting Plant Shift Boss
Casting Operator
Casting Helper
Electric Furnace Operator 1st

Category 2

Casting Shift Boss (Temp. Use)
Rubber Operator 1st (Zinc Plant)
Rubber Operator 2nd (Zinc Plant)
Labor Boss
Thse/Pstr/CP/Leaching Shift Boss
Thse/Leach/Cast/Foreman and Assist.
Zinc Plant General Foreman
Zinc Pes. Motorman
Zinc Plant Metallurgist
Head Operator
Head Caster
Head Moulder
Pilot Plant Operator
Pilot Plant Head Operator

Category 3

Zinc Clerk
Zinc and Zinc Plant Materials Technicians
Zinc Plant Technician Foreman
Experimental Helper
General Zinc Foreman
Exp. Man (Zinc Plt)
Experimental Man

G - <u>Zinc and Copper Roasters and Bedding Bins:</u>

Category 1

Roaster Shift Boss (Temp. Use Only)
Head Operator
Operator 1st
Operator 2nd
Special Operator (Swing Man)

Special Operator (Oxide Roaster)
Craneman
Conveyorman
Conveyorman Helper
Roaster Shift Boss (Temp. Use Only)
Roaster Feeder
Roaster Operator 1st
Roaster Operator 2nd
Roaster Operator 3rd
Tripper*
Receiving Bin Operator
Bedding Bins
Roustabout Roasterman
Cr/Helper
Roaster Shift Boss (Temp Use Only)
Roaster Plant Foreman
Zinc Roaster Helper
Roaster Helper
Roasterman
Roaster Feeder
Ball Mill Helper
CU Sulphate Roasterman
Roaster Operator (Zinc)
Roaster-Dryer Plant Shift 4-Man

Category 2

Repair Sub-Foreman
Repairman 1st
Repairman 2nd
Repairman 3rd
Repairman Helper
Oiler
Roaster Repairman Machine
Special Repairman

H - Department 40

CU Processing

Reverb Fuming Plant, Convertors Anode Casting:

Category 1

Head Feeder
Feeder Helper
Tapper 1st

Tapper 2nd
Furnace Helper
Skimmer
Puncher
Crane Man 1st
Crane Chaser 1st
Crane Chaser 2nd
Calcine Motorman
Calcine Brakeman
Bricklayers
Flue Cleaner
Laborer
Receiving Bin Operator
Fume Plant Operator 1st
Fuming Plant Operator 1st
Coal Operator
Baghouse operator 2nd
Fuming Plant Helper
Fuming Plant Operator 3rd
Smelter Bricklayer
Semlter Bricklay Helper 1st
Smelter Bricklayer Helper 2nd
Smelter Bricklayer Helper 3rd
Smelter Bricklayer Helper 4th
Bag Maintenance Man 1st
Bag Maintenance Man 2nd
Bag Maintenance Helper
Dryer Operator 1st
Dryer Operator 2nd
Dryer Operator 3rd
Dryer Helper
Dryer Tugger Operator
Dryer Clean-up Man
Calc. Brakeman
Converter Puncher
Feeder
Head Repairman
Flux Bin Man
Slag Tapper
Craneman Helper
Flux Pit Foreman

Category 2

Head Operator
Operator 1st
Operator 2nd
Operator 3rd

Repair Sub-Foreman
Repairman 1st
Repairman 2nd
Repairman 3rd
Repairman Helper
Oiler
Smelter Labour Foreman
Reverb Shift Boss
Spare Puncher
Gas Tester
Casting Machine Operator
Casting Machine Helper
Nipper
Fuming Plant Shift Boss
Rev/Rst BB/Anode Cst/Fum/Swng 4 men
Converter Foreman
Converter Shop Foreman
Converter Swing & Relief Shift Foreman
Operator Helper
Pachuca Helper
Smelter Miner
Tap Man
Mechanic
Casting Machine Operator
Crane Foreman
Matte Tapper Helper
Matte Tapper
Smelter Apprentice
Crane Helper
Crane Foreman

Category 3

Motorman (50 Ton) a Book
Brakeman (50 Ton) a Book
Stack Co-ordinator
Motorman
Brakeman
Motorman (50 Ton) only
Brakeman (50 Ton only)
Converter Shift Boss
Brakeman 3rd
Motorman 3rd
Track Foreman
Slag Trackman
Slag Track Helper
Sampleman
Weigher and Clerk
Control Room Operator
Smelter Clerk

Smelter & Smelter Materials Technician
Smelter Technician
Smelter Metallurgist
Sr. Smelter Metallurgist
Smelter Lbr. Boss/New Employee Coordin.
Rev/Conv/Fum Plt/Anode R-D Shift Boss
Smelter General Foreman
Slag Launderman
Flag Brakeman
Fuming Plant Foreman
Fuming Plant Shift Foreman
General Smelter Foreman
Shift Boss Casting Plant
Slag Motorman
Smelter Foreman
Foreman
Surface Safety Coordinator
Slag Brakeman
Moulder 1st
Shift Boss (Mech)
Head Sampler (Eng.)
Swing Shift Boss
Swing Foreman
Swing Boss
Convertor Shift Foreman

GENERAL

I - Department 60

Category 1

Craneman
Welder Sub-Foreman
Lead Acetylene and Elec. Welder
Acetylene and Electric Welder
Electric Welder
Industrial Mechanic Sub-Foreman
Lead Industrial Mechanic
Industrial Mechanic
Industrial Mechanic Apprentises
Electrical Welding Apprentices
Foundry Foreman
Lead Foundryman
Foundryman 1st
Foundryman 2nd
Foundryman 3rd

Foundry Helper
Foundry Sub-Foreman
Steel Nipper
Erector
Field Riverter

Category 2

Machinist Apprentices
Ass't. Plant Machnic Foreman
Machine Shop Foreman (Temp. Use)
Machine Shop Sub-Foreman
Lead Machinist
Machinist
Handyman 1st
Handyman 2nd
Bullgang Boss
Tool Repairman
Powersaw Operation
Machine Shop Helper
Radial Drill Press Operator 1st
Radial Drill Operator 2nd
Utility Man 1st
Punch Operator 1st or Utility Man
Flange Fireman or Punch Operation 2nd
Blacksmith Apprentices
Lead Blacksmith
Blacksmith Shop Sub-Foreman
Blacksmith
Hammerman
Blacksmith Shop Helper
Lead Tinsmith
Tinsmith Shop Sub-foreman
Tinsmith
Pipeshop Foreman (Temp. Use Only)
Pipeshop Sub-Foreman
Lead Burner
Pipe Fitter 1st
Pipefitter 2nd
Pipefitter 3rd
Pipeshop Helper
Lead Plumber
Laboror
Rigger Foreman
Rigger Sub-Foreman
Lead Rigger
Rigger 1st
Rigger 3rd
Rigger Helper
Industrial Mechanic

Repairman 2nd
Repairman 3rd
Repair Helper
Steamfitter and Plumber Apprentises
Sub-Foreman
Sr. Machn. Shop Mechanical Engineer
Const. Elec. Foreman
Inst. Mechanic 1st
Laborer CCS
Lumberman 2nd
Machine Shift Boss
Maintenance Man For Art Hrly.
Maintenance Mechanic Sub-Foreman Cert.
Maintenance Mechanic
Maintenance Mechanic (Stnd)
Maintenance Mechanic (Inter)
Maintenance Sub-Foreman
Moulder Sub-Foreman
Pipe Foreman
Pipefitter Foreman
Punch And Shear Operator 2nd
Shift Engineer
Shift Enineer 1st
Shop and Supply Man
Shop Finish Carpenter
Shop Pipeman
Steel Heater
Steel Shop Foreman
Steel Shop Helper
Steel Worker
Special Machinist Apprentice
Shop Handyman
Shop Bullgang Help
General Shop Helper
Pipefitter Helper
Shift Helper
Plant Painter
Steelman
Shop Helper
Labour Foreman
Repairman Helper
Machine Shop Shift Boss
Plant Electrical Foreman

Category 3

Tin and Coppersmith Apprentises
Garage Foreman
Garage Sub-Foreman
Lead Gas Mechanic
Gas Mechanic 1st

Gas Mechanics 2nd
Gas Mechanic 3rd
Pump Operator and Plant Patrol
Fire Chief
Sl Maint. Supt./Gen. 4-Men
Floor Mechanic
General Foreman--Industrial Mechanic
Layer-out
Floor Machine Helper
Floor Machine Helper
General Electrical Foreman

J - Boilermakers: (work throughout plant)

Category 1

Boiler Shop Sub-Foreman
Boilermaker
Boilermaker 2nd
Boilermaker Apprentises
Boilershop Maker
Lead Steam Fitter
Steam Fitter
Plumber
Steamfitter and Plumber Apprentices
Outside Boilermaker Shift Boss
Pipe/Underground/Machine-Boiler Shops.Repr. 4-Men
S. Fitter
Safety Boss
S.S. Helper
S.M. Man
Special Boilermaker Apprentice 1st
Special Boilermaker Apprentice 2nd
Spcial Boilmaker Apprentices 3rd
Special Boilermaker Apprentice 4th
Special Fitter Apprentice 1
Special Fitter Apprentice 3
Special Fitter Apprentice 4
Boilermaker Helper
Boiler Shop Surface Foreman

K - Rubber Workers:

Category 1

Rubber Worker Trainer
Rubber Sub-Foreman

Rubber Worker 1st
Rubber Operator 2nd (Zinc Plant)
Rubber Worker 3rd
Rubber Foreman
Rubber Operator 3rd
Rubber Plant Foreman
Rubber Shop Foreman
Rubber Experts

L - Department 64

Category 1

Coal Cottrell Man
Cottrell Operator 1st
Cottrell Operator 2nd
Coal Plant Operator 1st
Coal Plant Operator 3rd
Coal Handler
Laborer
Coal and Cottrell Helper
Coal Plant Operator
Coal Plant Cottrell Foreman
Cottrell Dustman
Coal Plant Helper
Coal Plant Sub-Foreman
Cont. Cottrell Helper
Contractor LW

Category 2

Coal Cottrell Foreman
Coal Cottrell Sub-Foreman
Cottrell Operator 3rd

M - Department 65

Powerhouse

Category 1

Sub-Foreman
Shift Sup. Eng. (Relief) 3rd class
Power Hse/Shift Eng. 3rd class
Shift Sup. Eng (Relief) 1st class
Shift Sup. (Releif) 2nd class

Power Hse Shift Eng. 1st
Power Hse Shift Eng. 2nd class
Engineer 1st class
Engineer 2nd class
Engineer 3rd class
Engineer 4th class
Stationary Engineer Apprentises
Power Plant Helper
Lead Powerhouse Mechanic
Powerhouse Mechanic
Powerhouse Mechanic 2nd
Laborer
Powerhouse mechanic 3rd
Powerhouse Handyman
Sub Station Operator 1st
Shift Supervisor
Shift Supervisor Engs 1st and 2nd
Powerhouse Foreman
Powerhouse General Foreman
Assistant Powerhouse Superintendent
Power Engineer Helper
Powerhouse Engineer
Powerhouse Helper
Powerhouse Shift Engineer
Powerhouse Swing Engineer
Substation Operator 1st
Sub-Station Maint Foreman (Elec)
Sub-Station Operator (Elec)

M - Department 66

Category 1

Lead Painter
Sign Painting
Painter 1st
Painter 2nd
Painter 3rd
Painter Apprentice
Journeyman Painter 1st
Journeyman Painter 2nd
Painter Helper

Category 2

Painter Foreman (Temp. Use Only)
Painter Sub-Foreman (Temp. Use)

O - Department 67

Category 1

Bricklayer Foreman
Bricklayer 1st
Refactory Bricklayer Apprentice
Laborer
Roustabout
Bricklayer Helper

Category 2

Lead Carpenter
Carpenter Foreman
Carpenter Sub-Foreman
Lead Carpenter
Carpenter 1st
Carpenter 2nd
Carpenter Helper
Carpenter 3rd
Carpenter Apprentice
Finisher
Finisher Helper
Carpenter Foreman
Carpenter Laborer
Carpenter Shop Foreman
Probation Shop Finish Carpenter
Rough Carpenter
Carpenter Jigger Boss
C H Caretaker
Carpenter

P - Department 68

Category 1

Relief Foreman (Temp. Use Only)
Foreman 1st
Foreman 2nd
Labour Sub-Foreman
Straw Boss
Foreman 3rd
Shovel Operator 1st
Shovel Operator 2nd
Shovel Operator 3rd
Shovel Oiler 1st
Shovel Oiler 2nd
Shovel Oiler 3rd

Locomotive Engineer 1st
Locomotive Engineer 2nd
Head Brakeman
Brakeman 1st
Brakeman 2nd
Dispatcher 1st
Dispatcher 2nd
Crane Operator 1st
Crane Operator 2nd
Crane Brakeman
Surface Miner
Powderman
Pumpman
Track Foreman 1st
Track Foreman 2nd
Trackman 1st
Trackman 2nd
Lead Blacksmith
Blacksmith
Bridgeman 1st
Bridgeman 2nd
Laborer
Surface Handyman
Rigger 3rd
Lead Rigger
Rigger 1st
Rigger 2nd
Rigger helper
Tractor Driver 1st
Tractor Driver
Bulldozer Operator 1st
Bulldozer Operator 2nd
Heavy Truck Driver
Median Truck Driver
Light Truck Driver
Junior Bullgang
Concentrate Sampler and Weigher
Truck and Train Busses/Dispatcher
Surface Foreman
Surface General Foreman
Bridgeman

Q - Department 69

Category 1

Instrument Mechanic Apprentices
Electrical Apprentices
Elec 4-Man (Temp.) Instru 4-Man (T)

Elec Sub-4-Man Instru Sub-4-Man
Elec 1 Tech 1 Instru Sub-4-Man
Elec 2nd Instru Mech 2nd Tech 2nd
Elec 3 Instru Mech 3 Tech 3
Lineman 1st
Lineman 2nd
Winder
Lineman and Electrical Helper
H T L Lineman Sub-Foreman
H T L Line Foreman (Temp. Use)
Assistant Substation Operator
Sub-Station Operator 1st
Sr. Elec Designer
Elec Technologist
Sr. Elec Research Engineer
Sub Statn/Const/Inst/Line/Elec/4-Men
Mine Elec Foreman
Mine Elec Foreman
Electrical Lineman
Lineman Sub-Foreman
Plant Electrical Sub-Foreman
Special Electrician Apprentice 1st
Special Electrician Apprentice 2nd
Special Electrician Apprentice 3rd
Electric Helper
Line Foreman
Chief Maint Foreman (Elec)
Mine Electrical Sub Foreman

R - Department 70

Category 1

Experimental Operator
Env. Trainer Asst. Lab Techn.
Sampler and Jr. Air Techn.
Jr Assy/Sample Pres/Air/Water
Process/Assy/Mat/Sampling Techns
Air/Water/Process/Assey Techns
Lab Technician
Lab Technician
Sr. Lab Technologist
Sr. Lab Technologist
Analytical Supervisor
Assay Sampler
Assay Technician
Assayer
Test Plant Shift Boss
Tester
Jr Safety Helper (Safety)
Test Plant Craneman

Category 2

Sampler
Laborer - Department 72
Safety Engineer Helper - Department 72
Shipping Clerk
Metals Clerk
Concentrate Co-ordinator
Plt. Sfety Tech/First Aid Instrctr - Department 72
Jr. Process Eng.
Suf and Mine Safety Co-ordinators - Department 72
Process Scientists/Sr. Lab Techn.
Process Eng.
Section Leader
Section Leader
Safety Engineer - Department 72
Section Leader
Sr. Safety Engineer - Department 72
Supt. of Safety - Department 72
Chief Chemist
Group Leader (Analyst)
Jr. Clerk Zinc Plant
Research Clerk
Special Chemist Helper
Junior Chemist
Junior Geologist
Junior Engineer Helper
Research Operator
Assey Camp W (ECPT)
Lab Messinger (ECPT)
Assistant Safety Engineer
Junior Shift Boss
Research Operator
Chemist
Junior Chemist

S - NO EXPOSURE

Department 60

Plant Office Clerk
Senior Office Clerk
Biologist and Agronomist
Sr. Mechanical Technologist

Department 70

Biologist and Agronomist

Department 71

Key Punch Trainee
Key Punch & Key Verifier Operators
Asst. Data Control Clerk
Data Control Clerk
Sr. Keypunch Operator
Data Proc. Clerk Steno
Jr. Programmer and Jr. Comp. Operator
Programmer and Computer Operator
Jr. Syst. prog Analy/Sr. Comp.Opr
Systems Analyst
Sup Prog/Sr. Systems Analy/Sup Oper
Supervisor Sytem and Programming

Department 72

Safety Clerk

Department 73

Sr Buyer
File Clerk
Order Proc Clerk Typist
Freight Acct Clerk Telex Operator
Punch Clerk Steno
Expeditor
Jr Buyer
Buyer

Department 74

Payroll Clerk-Typist
Payroll Clerk
Sr. Clerk Payroll
Payroll Supervisor

Department 75

Senior Engineer Helper
Engineers Helper 1st
Engineers Helper 2nd
Labourer
Reproduction Machine Operator
Engineering Trainee
Jr. Draftsman/Surv Hlpr/Eng. Trainee
Sr. Clerk-Design & Draft/Eng. Trainee
Draftsman Jr Designer
Instrument Man Eng. Trainee
Sr. Draftsman Survey Leader
Sr. Draftman
Sr. Draftsman Designer
Jr. Engineer Designer
Project Co-ordinator
Sr. Designer
Project Co-ordinator
Project Co-ordinator
Cost Eng Eng-Design
Design Co-ordinator Sl Mill Proj
Chief Draftsman
Sr Engineer - Design
Chief Designer

Department 76

Checker 1st
Checker 2nd
Checker 3rd
Labourer
Chief Inventory Clerk
Jr Clerk or Whse Office Clerk
Whse Clerk-Typist
Whse Terminal Operator
Jr Checker or Whse Janitor
Typist or Whse Clerk-Steno
Checker and Clerks (Whse)
Sr. Clerk (Stock Control)
Sr. Clerk (Inv Data)
Whse and Asst. Whse Foreman

Department 77

Sales Tax Analyst

Gen and Cost Account/Gen Acct Superv
Jr. Clerk
Acct Clerk 1 (Inv Val)
Acct Clerk 11 Rec/Pay and Sub/N Power
Security Accounting
Acct Clerk 3 (Payable)
Emp Off and Coord/Sr Clerks (Depis)
Sr Min Cl/Pen Ben IR Pr Officers
Secretary to GM
Emp/Training and Dev/Wage and Sal/Supervis
Geological Draftsperson
Industrial Editor Job Analyst
Industrial Nurse

Department 79

Services Carpenter
Straw Boss/Gardener/Relief Cook
Handyman
Caretaker
Labourer or Janitor
Security Offier
Watchman
Special Duty Watchman
Security Foreman (Relief)
Security Officer
Security Foreman
Chief Security Officer

Department 80

Handyman
Labourer
Cookkee
Jr. Clerk Central Reproduction
Waitress Opr 2nd
Baker Operator 2nd
Waitress Opr 1st Main 1st
Tour Guide
Baker Operator 1st
Technician-Central Reproduction
Sr Technician-Central Reproduct
Resort/Sh/Gardns-Maint Supervisor
Supervisor Security and Servies

Department 83

Jr IE Analyst
IE Analyst
Sr IE Analyst
Proc Dev and Sr IE Analysts
Industrial Engineer
Chief IE Analyst
Chief IE Analyst

Department 84

Shaft Jigger Boss - HBED
Miner - HBED
Mine Sampler Geophsical Trainee
Geophysical Opr Yard Man
Geo Crew Chief-Ground
Geo Crew Chief-Ground
Drill Geologist Rainee
Field Coord/Accts and Spec Projects
Field Geologist
Field Geologist
Field Geologist
Mine Geologist
Mine Geologist
Asst Sup Diam Dril-M, in Land/Field G
Struct Geol/Sr Min Geol FF-Sl/Syuper
Supervisor-Diamond Drill/Geophysics

Department 85

Cargo Handler
Appr Aircraft Maint Engineer
Aircraft Maintenance Engineer
Pilot
Chief Engineer Crew Chief
Chief Pilot

Department 86

Handyman
Labourer or Electrical Appr Crp
Casual and Temp Labourer

Utility Man
Sr Clerk-Crp
Operator Trainee
Third Operator
Second Operator
Maintenance Man 1st
Opr 1st Maintenance Ass 4-Men
Elec Technologist
Operator Tecnician
Watchman Dam Attendant
Chief Operator

Department 87

Planner Trainee
Jr Planner
Maintenance (Inspect/Planner/Coord)
Sr Planners (Prod/Plt Service/Sl)
Chief Maintenance Planner

Department 88

Mill Project Clerk
Proj Cost Accountant/Mai Control
Co-ordinators (Civil/Mechanical)
Co-ordinators (Civil/Mech/Elec)
Design Co-ordinator
Clerks and Timekeepers (Depts)
Assistant Plant Fireman
Assistant Storekeeper
Browning Fireman
Browning Runner
Camp Labour
Central Office Head Clerk
Clerical Assistant To The General Superintendent
Commissary Manager
Cost Accountant
Dam Attendent
Draftsman
Gardener
Laborer (Grounds)
Loco Fireman
Metallurgical Accountant
Metallurgical Plants Maintenance Foreman
Night Watchman
Office Boy

Power Company Manager
Prospector
Sewing Room Tailor
Senior Lab Technologists
Special Assistant Watchman Foreman
Special Plant Watchman
Special Watch Foreman Assistant
Stable Foreman
Telephone Operator
Warehouse Checker 1st
Warehouse Checker 2nd
Watchman Foreman
Special Watchman Foreman
Browning Operator
Head Mine Repairman
Personnel Clerk
Personnel and Industrial Relations Management Occupations
Personnel and Other Related Officers
Senior Engineer Hipr
Changehouse Caretaker
Weigh Mater Junior Clerk
Clerk
Burner
Outside Repairman 2nd
Outside Repairman 3rd
Outside Repairman
Fireman
Fireman 3rd
Fireman 1st
Fireman 2nd
Fireman Helper
Surface Helper
Teamster
Warehouse & Warehouse Helper
Day Foreman (Surface)
Tractor Driver
Patrolman
Senior Shift Boss
Office Clerk
Supt Surface and Transporatation
Geologist

T - Cadmium Strippers

Category 1

Cadmium Operator
C.P.Weigher

Cadmium Control Operator
Cadmium Stripper
C P Charger

TABLE 1

QUANTATIVE EXPOSURE

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND
A - Department 10																
Underground:																
Category 1	.152						?	.51	.160	.285	.158					1.26
Category 2	?						?	?	.213	?	.033					.246
Category 3	?						?	?		?	?					

Total Dust - mg/m^3
Zn - Zinc - mg/m^3
As - Arsenic - mg/m^3
Cd - Cadmium - mg/m^3
Cu - Copper - mg/m^3
Pb - Lead - mg/m^3
Resp. Dust - Respirable Dust - mg/m^3
SiO_2 - Silicon Dioxide - mg/m^3

CO_2 - Carbon Dioxide - PPM
NO_2 - Nitrogen Dioxide - PPM
CO - Carbon Dioxide - PPM
AsH_3 - Arsine - mg/m^3
H_2SO_4 - Sulfuric Acide - mg/m^3
CN - Cyanide - mg/m^3
Asb - Asbestos - f/cc
IND - Accumulated T.L.V.

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND
TABLE 2																
Department 20																
B - Crusher:																
Category 1	.466	.010	.020	.000	.002		?	?								.539
TABLE 3																
C - Mills:																
Category 1	?						.79	?								.79
Category 2	?						?	?								

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

Department 30

TABLE 4

Zinc Processing

D - Leaching:

Category 1	.231	.050	.030	.020	.003	.031						?		?		.365

TABLE 5

E - Tankhouse:

Category 1													.96*			.96*
Category 2													?			

* **Sampling Time - April - November: 1.47**
May - October: .60

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 6

F - Zinc Casting:

Category 1	.693	.842	.050	.000	.004	.052			?						?	1.641
Category 2	.070	.050	.050	.020	.003	.001			?						?	.194
Category 3	?	?	?	?	?	?			?						?	

TABLE 7

G - Zinc and Copper Roasters and Bedding Bins:

Category 1	.624	.307	.095	.140	.475	.066	?	?	7.134						?	8.841
Category 2	.427	.383	.155	.140	.042	.024	?	?	2.022						?	3.193

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 8

H - Department 40

CU Processing

Reverb Fumming
Plant Conveters
Anode Casting:

Category 1	.665	.188	.135	.280	.816	.057	?	?	1.541	?				?	3.683	
Category 2	.470	.081	.095	.080	.151	.027	?	?	1.952	?				?	2.856	
Category 3	?	?	?	?	?	?	?	?		?				?		

GENERAL

TABLE 9

I - Department 60

Category 1	.738	.087	.010	.000	.360	.056	?	?	?					?	1.251	
Category 2	?	?	?	?	?	?	?	?	?					?		
Category 3	?	?	?	?	?	?	?	?	?					?		

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 10

J - Boilermakers:

Category 1	?	?	?	?	?	?	?	?	?						?	

TABLE 11

K - Rubber Workers

Category 1	POSSIBLE SOLVENT EXPOSURE

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 12

L - Department 64:

Category 1	?	?	?	?	?	?	15.8	?							?	15.8
Category 2																

TABLE 13

M - Department 65

Powerhouse:

Category 1	POSSIBLE P.C.B.'s

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 14

N - Department 66

Category 1	POSSIBLE SOLVENT EXPOSURE
Category 2	POSSIBLE SOLVENT EXPOSURE

TABLE 15

O - Department 67

Category 1	?	?	?	?	?	?	?	?	?		?					
Category 2	?						?									

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 16

P - Department 68

Category 1	?						?	?								

TABLE 17

Q - Department 69

Category 1	POSSIBLE P.C.B.'s															

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 18

R - Department 70

Category 1	.211	.061	.015	.080	.185	.073	?	?								.625
Category 2	?	?	?	?	?	?	?	?								

TABLE 19

S - NO EXPOSURE - (from the following departments)

Department 60, 70, 71, 72, 73, 74, 75, and 76

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

Job Exposure Category	Total Dust	Zn	As	Cd	Cu	Pb	Resp Dust	SiO_2	SO_2	NO_2	CO	AsH_3	H_2SO_4	CN	Asb	IND

TABLE 20

T - Cadmium Strippers

Category 1	.070	.075	.005	.580	.007	.002			?							.739
Category 2	.129	.051	.005	.900	.004	.002			?							1.091

Total Dust - mg/m^3
Zn - Zinc - mg/m^3
As - Arsenic - mg/m^3
Cd - Cadmium - mg/m^3
Cu - Copper - mg/m^3
Pb - Lead - mg/m^3
Resp. Dust - Respirable Dust - mg/m^3
SiO_2 - Silicon Dioxide - mg/m^3

SO_2 - Sulfur Dioxide - PPM
NO_2 - Nitrogen Dioxide - PPM
CO - Carbon Dioxide - PPM
AsH_3 - Arsine - mg/m^3
H_2SO_4 - Sulfuric Acide - mg/m^3
CN - Cyanide - mg/m^3
Asb - Asbestos - f/cc
IND - Accumulated T.L.V.

NOTE: All values are reported as a fraction of each contaminant's respective TLV.

CHAPTER IV

MORTALITY IN FLIN FLON, MANITOBA

1959 - 1983

R. SEMENCIW (1)

J. MANFREDA (2)

(1) NON-COMMUNICABLE DISEASE DIVISION, BUREAU OF EPIDEMIOLOGY, LABORATORY CENTRE FOR DISEASE CONTROL, HEALTH AND WELFARE CANADA

(2) DEPARTMENTS OF MEDICINE AND SOCIAL AND PREVENTIVE MEDICINE, UNIVERSITY OF MANITOBA.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHODS	1
RESULTS	2
RESPIRATORY DISEASE	3
CURCULATORY DISEASE	3
ALL CANCERS	3
CANCER OF TRACHEA, BRONCHUS AND LUNG	4
DIGESTIVE TRACT CANCERS	4
OTHER CANCERS	5
ACCIDENTS, POISONING, VIOLENCE	5
DISCUSSION	5
ACKNOWLEDGEMENTS	8
REFERENCES	8
APPENDIX 1	9
TABLES	

INTRODUCTION:

This report was prepared at the request of the Workplace Safety and Health Division, Manitoba Department of Environment and Workplace Safety and Health. It results from concerns which have been expressed regarding possible environmental and occupational health hazards in Flin Flon, the center of the mining and smelting operation of the Hudson Bay Mining and Smelting (HBM&S) Company. The report consists of an analysis of mortality patterns in Flin Flon compared to Manitoba as a whole and to five communities in Manitoba (Dauphin, The Pas, Brandon, Steinbach and Portage la Prairie) and one community in Saskatchewan (Creighton).

METHODS:

In Manitoba, all towns and cities with a population of 6,000 - 40,000 except Thompson and Selkirk, were selected as comparison communities. Thompson was excluded because its population varied more than other communities during the study period. Selkirk was excluded since it was considered an extension of metropolitan Winnipeg. Creighton was selected in spite of its size (approximately 2,000 residents) because it is situated 3 km west of Flin Flon and shares with it the same environment. Most male residents in Creighton work for the HBM&S Company.

Death data for the areas under study for the period 1959 - 1983 were selected from the National Mortality Database of Statistics Canada. Population data were available from the 1961, 1966, 1971, 1976 and 1981 censuses of population (1-5). Person-Years at risk for each five year period centered around a census were calculated by multiplying the census population by five.

Mortality was assessed using age-standardized mortality rates (ASMRs) and standardized mortality ratios (SMRs) to adjust for any difference in age distributions between Flin Flon and the comparison areas.

SMRs are the ratios of observed to expected number of deaths in the area under study. The expected values were calculated by applying sex, age and cause specific mortality rates to the population distribution of the study area. Provincial mortality rates were used to generate the expected number of deaths. Confidence intervals for the SMRs were calculated using a Poisson ratio test (6), which is the most appropriate for testing rare events. The SMR was considered significantly elevated, indicating an excess of mortality, if the lower limit of the 95 percent confidence interval did not include 1.00. The SMR was significantly lower than expected if the upper limit of the 95 percent confidence interval did not include 1.00.

Cause and sex-specific ASMRs for the communities under study for each year were calculated by applying standard weights (the 1971 Canadian

population) to the age specific rates. These were then compared with corresponding rates for Manitoba.

Results of this analysis are based on the underlying cause of death recorded on the death certificate which was coded to the revision of the International Classification of Diseases (ICD) in effect in the year of death. It should be noted that causes are not mutually exclusive. For example, all-site cancer mortality was examined as well as cancer mortality rates for specific sites. The range of ICD codes used for each cause is available upon request.

In studying mortality at a sub-municipality level, the importance of correct residence coding is obvious. There is a tendency to attribute death to adjacent urban centres (7). For this reason, where possible, results are presented by areas functioning as economic units. A complete list of census subdivisions used is given in Appendix 1.

RESULTS:

Between 1959 and 1983, there were 924 deaths among male and 523 among female residents of Flin Flon. Both male and female mortality were above the provincial level (9% and 6%, respectively). The excess mortality was significant in males (SMR = 1.09, 95% CL: 1.03 - 1.17) but not in females (SMR = 1.06, 95% CL: 0.97 - 1.16). In males, the excess was greater in age group 65+ (SMR = 1.16, 95% CL: 1.05 - 1.28) than in the 20 - 64 year age group (SMR = 1.06, 95% CL: 0.95 - 1.17). In females, the opposite was true: the excess mortality was greater in the 20 - 64 year age group (SMR = 1.09, 95% CL: 0.94 - 1.26) than in those older than 64 years (SMR = 1.03, 95% CL: 0.90 - 1.17) (Table 1).

In comparison with the provincial standard, the excess mortality was higher in the most recent ten years (1974 - 1983) than previously (1959 - 1973) for both males (SMR = 1.13, 95% CL: 1.02 - 1.25) and females (SMR: 1.16, 95% CL: 1.03 - 1.32). Between 1974 and 1983, the excess mortality from all causes was significant in both sexes.

In The Pas, the SMRs for all causes (1959 - 1983) were higher than in Flin Flon for both males (SMR = 1.39) and females (SMR = 1.38). On the other hand, SMRs were lower in the remaining communities: Creighton (SMR = 1.05 for males and SMR = 1.05 for females), Dauphin (1.01 and 0.95), Brandon (0.92 and 0.89), Steinbach (0.85 and 0.86), and in Portage la Praire (1.01 and 1.02) than in Flin Flon (Table 1).

The SMRs for Flin Flon were systematically examined for 39 diagnostic categories. Results are shown in Tables 2 and 3 for males and in Tables 4 and 5 for females. Although the SMRs were greater than one for 25 diagnostic categories in males and 16 in females, the excess was significant only for all accidents, all cancers, cancer of trachea, bronchus and lung and COPD (chronic obstructive pulmonary disease: chronic bronchitis, emphysema, and asthma) in men and for all respiratory diseases in women.

The Flin Flon SMRs are compared with those from six other communities in Tables 6 and 7 for males and in Tables 8 and 9 for females. Overall, Creighton resembles Flin Flon: the SMR's were elevated in all categories in which there was a significant mortality excess in Flin Flon except COPD in males and respiratory diseases in females. However, excesses are not significant due to the small number. In comparison with Flin Flon, SMRs in The Pas tended to be higher for non-cancer and lower for cancer categories. SMRs were higher in Flin Flon than in Dauphin, Brandon, Steinbach and Portage la Prairie for both males and females for the following diagnostic categories: all causes, all respiratory diseases, all cancers, cancer of large intestine and rectum, bladder cancer, COPD, kidney diseases and suicide. For males only: accidents, cancer of esophagus, cancer of liver, cancer of digestive tract, cancer of trachea, bronchus and lung, cancer of kidney, lymphoid cancers, cerebrovascular diseases, accidental falls, drownings and homicide. In females only: cancer of tongue, mouth and pharynx, cancer of breast, cancer of ovaries, diabetes, cirrhosis of liver, accidental fires.

RESPIRATORY DISEASES:

There was an excess of respiratory diseases (excluding cancers of the respiratory tract) in both males (19%) and females (52%) in Flin Flon. Only the excess in females was signficant. SMR's for COPD (chronic bronchitis, emphysema, and asthma) were elevated in both males (SMR = 1.55, significantly) and females (SMR = 1.54, non-significantly); SMR's were also elevated in both males and females in The Pas (1.63 and 1.64, respectively) and in Brandon (1.42 and 1.25). In Portage la Prairie, they were close to the provincial average (1.06 and 0.98) while in Dauphin, they were elevated in males (1.32) but not in females (0.86).

CIRCULATORY DISEASES:

In both sexes, mortality due to circulatory diseases in Flin Flon was at (males: SMR = 1.00), or below (females: SMR = 0.94) the provincial average. This is true for mortality due to major cardiovascular diseases or to IHD (ischemic heart disease). SMRs for IHD ranged from 0.91 (Steinbach) to 1.13 (The Pas) for males and 0.70 (Creighton) to 1.33 (The Pas) for females. For both sexes, Flin Flon was in the center of the range which was wider in females than in males.

ALL CANCERS:

In males there were 206 deaths ascribed to cancer. This represents a significant excess of 34 deaths (or 20%) over the expected number. The SMR was greater than 1.00 for cancer of stomach (1.21), large intestine and rectum (1.11), liver (4.20), pancreas (1.46), all digestive tract (1.24), trachea, bronchus and lung (1.32), prostate (1.07), bladder (1.53), lymphoid (1.41). Only for cancer of the trachea, bronchus and lung was the excess significant. The most common cancer sites were trachea, bronchus and lung, large intestine including rectum, and

stomach; cancers of the respiratory and digestive tract accounted for 65 percent of all cancers in males.

In females, one less cancer death occurred than was expected (122 observed vs 123 expected deaths). The SMR was greater than 1.00 for cancer of tongue, mouth and pharynx (4.93), esophagus (2.70), large intestine and rectum (1.18), trachea, bronchus and lung (1.31), and bladder (3.49). The excess was not significant for any cancer category. Most common cancer sites were breast, large intestine including rectum, and trachea, bronchus and lung. In comparison with males, a smaller proportion of all cancers in females was accounted for by cancers of the respiratory and digestive tract (38.5%).

CANCER OF TRACHEA, BRONCHUS AND LUNG:

In Flin Flon, there was an excess of 16 cancers of trachea, bronchus and lung in males (32%). Similarly, there was an excess in Creighton (8 observed vs 5.27 expected, SMR = 1.52) and to a smaller degree in Dauphin (11%). While the expected number occurred in The Pas, the SMRs were much lower for Brandon (0.85), Steinbach (0.77) or Portage la Prairie (0.74).

Figure 1 shows the SMRs for Flin Flon and other communities for five 5 year periods. It can be seen that there was a great variability in the SMR from period to period particularly for Flin Flon, The Pas and Dauphin. SMRs for Brandon, Steinbach and Portage la Prairie were less variable and were consistently below the SMR of 1.00. On the other hand, the SMR for Flin Flon was greater than 1.00 in all but one period (1969 - 1973) and those for The Pas and Dauphin were elevated in two 5 year periods.

In females, the excess (31% or 3.3 deaths) was not significant; the SMRs in other communities were approximately 1.00 (The Pas and Brandon) or less (Creighton, Dauphin, Steinbach, Portage la Pairie).

DIGESTIVE TRACT CANCERS:

In both sexes, the major contributors to digestive tract cancers were cancer of stomach, large intestine including rectum and pancreas. The high SMR for liver in males (4.20) and for tongue, mouth and pharynx in females (4.93) are based on one observed case of death. SMRs for all digestive tract cancers suggest an excess in males (1.24, non-significant) but not in females (0.88). For all digestive tract cancers, the SMRs in Flin Flon were higher than those in Dauphin, Brandon, Steinbach, Portage la Prairie and were lower than those in Creighton and The Pas. In females, the Flin Flon rate was higher than the rate in Creighton and Dauphin, similar to the rate in Brandon and lower than those in The Pas, Steinbach or in Portage la Prairie. In males

there was a non-significant excess of cancer of the stomach (SMR = 1.21), pancreas (SMR = 1.46), large intestine and rectum (SMR = 1.11). In females, the excess was only for large intestine and rectum (SMR = 1.18).

Figures 2 and 3 show the digestive tract cancers in Flin Flon for 5 year intervals for males and females, respectively. Data for males suggest that the excess was limited to the period prior to 1974. In females, the excess was found in the more recent period.

OTHER CANCERS:

Cancer of the bladder was elevated, although not significantly, in Flin Flon in both males (8 observed vs 5.21 expected, SMR = 1.53) and females (3 vs 0.86, SMR = 3.49). The SMR was higher in Flin Flon than in the comparison communities. In males, the excess seems to be limited to the period prior to 1974.

The SMR for the cancer of the prostate was slightly elevated (1.07) representing one excess death. The Flin Flon rate is similar to that in Dauphin, in The Pas and Portage la Prairie and slightly higher than in Brandon and Steinbach.

The frequency of brain cancer as a cause of death was less in males than expected (3 observed vs 5 expected, SMR = 0.59) (Table 3). In both sexes, this SMR was lower than in comparison communities (Tables 7 and 9).

Lymphoid cancer was elevated in males (14 observed vs 10 expected, SMR = 1.41), but not in females (5 vs 7, respectively, SMR = 0.73) (Tables 3 and 5).

ACCIDENTS, POISONINGS, VIOLENCE:

In Flin Flon males, there was a significant excess (23%, SMR = 1.23) of deaths due to accidents, poisonings or violence (Table 2). This was due to excess in several categories: motor vehicle traffic accidents (MVTA, 6%), falls (28%), fires (17%), drownings, (1%), suicide (36%) and homicide (41%). In females (Table 4), accidents, poisonings, or violence caused fewer deaths than expected (SMR = 0.83) although there was an excess of suicides (11 observed vs 6 expected, SMR = 1.76).

DISCUSSION:

In this analysis, the mortality pattern between 1959 and 1983 in Flin Flon was compared with that for the province as a whole and with six other communities. Results suggest that, during this period, the mortality of males in Flin Flon was significantly above the provincial average for all causes, all cancers, cancer of trachea, bronchus and lung, COPD and accidents. In females only mortality due to all respiratory diseases was significantly elevated. The excess of mortality from all causes was significant for both sexes for the period

between 1974 and 1983. In addition to being above the provincial average, mortality for selected causes in Flin Flon was higher than in most of the six similar sized comparison communities in the province.

Such results could have been produced by several biases. However, there is no evidence that there was during the period analyzed, a systematic bias between Flin Flon, other communities and the province with respect to certifying the underlying cause of death or estimating the population. The estimates of the population were obtained for all communities as well as for the province by censuses which were carried out between 1959 and 1983. Definition of population by economic unit, rather than by strict community boundaries, should have improved the quality of data. The results of the analysis could have been affected by a higher turn-over of the population in Flin Flon. Too little is known about the magnitude and type of migration in and out of Flin Flon in comparison with other communities to assess the effect of this migration on results in the analysis.

Results of the analysis should be considered cautiously. The size of communities was small. While the range was from 2,000 (Creighton) to 30,000 residents (Brandon), most communities (Flin Flon, The Pas, Dauphin, Steinbach and Portage la Prairie) had populations between 6,000 and 12,000. Because of the small population size, the expected number of deaths was small in many diagnostic categories in spite of the 25 year period studied. In Flin Flon, the expected number of deaths was less than 5 in several diagnostic categories.

It should be pointed out that because many comparisons were made, several should have been expected to be significant by chance. No correction for multiple testing was made.

Data suggests that Flin Flon had a higher mortality from all causes than other communities in the province except The Pas for both males and females. Even in The Pas, the SMR for all cancers was lower than in Flin Flon. This could be due to a large proportion of the native population amongst whom the risk of cancer is reduced (8). Populations in Creighton and in Flin Flon had similar occupational and general environmental exposures. The mortality pattern was also similar in both communities although it is difficult to interpret the mortality in Creighton because of small numbers. However, if data for Creighton are added to those for Flin Flon, the excess mortality in Flin Flon increases for most causes.

The mortality due to accidents was significantly elevated in Flin Flon males but not in females. If the excess deaths attributed to accidents (26 in number) are subtracted from the observed deaths for males in Flin Flon, there is still an excess of mortality from all causes although it is diminished from SMR = 1.09 to SMR = 1.06. The excess in mortality from all causes for either males or females can therefore not be explained by deaths due to accidents.

Cancers contributed to excess mortality in both sexes, although the SMR for all cancers was significantly elevated only in males. Over the 25 year period, there were 34 excess cancer deaths in men or 1.4 per year. Most of these were due to cancers of the digestive tract (13 in number) and cancer of trachea, bronchus and lung (16 in number). Figures 1 and 2 show that this excess was not uniformly distributed over time. For digestive tract cancers, the trend varied for cancers of different sites. Figure 1 further suggests that the excess for cancers of the digestive tract was higher prior to 1964.

Respiratory diseases were a contributor of excess deaths in both sexes, although the numbers were significant only in females. In males the excess deaths were due to COPD.

In this analysis it was not possible to identify factors responsible for elevated mortality from selected causes in Flin Flon. Several hypotheses can be entertained. These hypotheses consider the possible role of occupational factors due to employment of a large proportion of the population in the local mining/smelting industry, pollution of the environment by emission from the smelter, or lifestyle factors such as smoking.

These hypotheses cannot be tested in the present analysis. The excess mortality was less convincing in females than in males. Few females were employed and exposed to occupational factors in the mining/smelting industry. An excess in female mortality could have been ascribed to factors in the general environment. The absence of such excess suggests that the general environment can not be a major cause of excess mortality.

The excess mortality in males is consistent with the occupational or smoking hypothesis. The smoking hypothesis is consistent with the finding that in males (and to some extent also in females), the main contributor to excess deaths are diseases which are known to be associated with smoking such as lung cancer and COPD. There is no reliable information on smoking habits in the province and in the comparison communities including Flin Flon which would make it possible to evaluate the hypothesis that differences in SMRs for lung cancers and COPD could be accounted for by differences in smoking habits. Theoretically, an SMR between 1.20 and 1.35 could be explained by increased smoking. On the other hand, it is more questionable if a difference between SMR = 0.74 (Portage la Prairie) and 1.32 (Flin Flon) for lung cancer could be attributed to smoking alone.

ACKNOWLEDGEMENTS:

We thank John Sillins, Chief, Vital Statistics and Disease Registries Section, Health Division, Statistics Canada, for supplying the death data.

REFERENCES:

1. Statistics Canada. 1981 Census of Canada, Population, Selected characteristics, Ottawa, Canada: Minister of Supply and Services, 1982. (catalogue no. 93-918)

2. Statistics Canada. 1976 Census of Canada, Supplementary Bulletins, Geographic and Demographic. Ottawa, Canada: Minister of Supply and Services, 1978. (catalogue no. 92-835)

3. Statistics Canada. 1971 Census of Canada, Special Bulletin, Population. Ottawa, Canada: Minister of Industry, Trade and Commerce, 1973. (catalogue no. 92-772)

4. Dominion Bureau of Statistics. 1966 Census of Canada, Special Bulletin, Population. Ottawa, Canada: Minister of Trade and Commerce, 1968.

5. Dominion Bureau of Statistics. 1961 Census of Canada, Special Bulletin, Population. Ottawa, Canada: Minister of Trade and Commerce. (catalogue no. 92-525).

6. Ury H, Wiggins A. Another Shortcut Method for Calculating the Confidence Interval of Poisson Variable. Am J Epid 1985; 122:197-198.

7. Mao Y, McCourt C, Morrison Hl et al. Community-based Mortality Surveillance: The Maniwaki Experience. Investigation of Excess Mortality in a Community. Can J. Pub. Health 1984; 75:429-433.

8. Young, TK, Choi N. W. Cancer Risks Among Residents of Manitoba Indian Reserves, 1970 - 79. Canadian Medical Association Journal 1985; 132: 1269-1273.

Appendix 1

FUNCTIONAL BOUNDARIES OF COMMUNITIES

Community	Components
1. Flin Flon	Flin Flon C (Manitoba) Flin Flon C (Saskatchewan)
2. Creighton	Creighton T (Saskatchewan)
3. Dauphin	Dauphin T Dauphin RM
4. The Pas	The Pas T
5. Brandon	Brandon C Cornwallis RM Elton RM
6. Steinbach	Steinbach T Hanover RM Niverville VI
7. Portage la Prairie	Portage la Prairie C Portage la Prairie RM

C = City
T = Town
VI = Village
RM = Rural Municipality

TABLE 1

MORTALITY FROM ALL CAUSES 1959 - 83

Community	Age	NUMBER OF DEATHS Observed	Expected	SMR	95% CONFIDENCE LL	UL
MALES						
FLIN FLON	ALL	924	844	1.09	1.03	1.17
	20-64	382	362	1.06	0.95	1.17
	65+	397	342	1.16	1.05	1.28
CREIGHTON	ALL	109	104	1.05	0.86	1.26
DAUPHIN	ALL	1876	1865	1.01	0.96	1.05
THE PAS	ALL	848	609	1.39	1.30	1.49
BRANDON	ALL	4551	4965	0.92	0.89	0.94
STEINBACH	ALL	1140	1335	0.85	0.80	0.90
PORTAGE	ALL	2524	2503	1.01	0.97	1.05
FEMALES						
FLIN FLON	ALL	523	439	1.06	0.97	1.16
	20-64	194	178	1.09	0.94	1.26
	65+	230	222	1.03	0.90	1.17
CREIGHTON	ALL	56	53	1.05	0.79	1.36
DAUPHIN	ALL	1168	1233	0.95	0.89	1.00
THE PAS	ALL	454	328	1.38	1.26	1.52
BRANDON	ALL	3411	3849	0.89	0.86	0.92
STEINBACH	ALL	816	947	0.86	0.80	0.92
PORTAGE	ALL	1751	1718	1.02	0.97	1.07

SMR = Standard Mortality Ratio

LL = Lower Limit

UL = Upper Limit

TABLE 2

MORTALITY IN FLIN FLON 1959 - 83

MALES: ALL AGES

Cause of Death	Code	NUMBER OF DEATHS Observed	Expected	S.M.R.	95% CONFIDENCE LL	UL
All Causes	001-999	924	844.30	1.09	1.03	1.17
Diabetes Mellitus	250	8	8.96	0.89	0.39	1.75
Circulatory Diseases	390-459	371	369.83	1.00	0.90	1.11
Major Cardiovascular	390-448	361	363.72	0.99	0.89	1.10
Ischemic Heart Dis.	410-414	246	254.06	0.97	0.85	1.10
Cerebrovascular	430-438	60	53.81	1.12	0.85	1.43
Rheumatic Fever/Heart	390 - 448	9	5.96	1.51	0.69	2.85
Respiratory Diseases	460-519	81	68.20	1.19	0.94	1.48
COPD	490-493,496	36	23.29	1.55	1.08	2.14
Ulcers	531-534	5	5.24	0.95	0.31	2.19
Cirrhosis of Liver	570	6	11.96	0.50	0.18	1.08
Kidney Diseases	580-593	13	7.82	1.66	0.89	2.83
Congenital Anomalies	740-759	8	12.15	0.66	0.28	1.29
Accidents/Violence	800-899	135	109.45	1.23	1.03	1.46
MVTA	810-999	35	32.94	1.06	0.74	1.48
Accidental Falls	880-888	10	7.79	1.28	0.62	2.35
Accidents: Fires	890-899	6	5.14	1.17	0.43	2.51
Accidental Drowning	910	7	6.96	1.01	0.40	2.05
Suicide	950-959	30	22.04	1.36	0.92	1.94
Homicide	960-969	5	3.55	1.41	0.46	3.23

COPD = Chronic Obstructive Pulmonary Disease (Chronic Bronchitis, Emphysema, Asthma)
MVTA = Motor Vehicle Traffic Accidents

TABLE 3

MORTALITY IN FLIN FLON 1959 - 83

MALES: ALL AGES

CAUSE OF DEATH		NUMBER OF DEATHS			95% CONFIDENCE	
Cancer	**Code**	**Observed**	**Expected**	**S.M.R.**	**LL**	**UL**
All Sites	140-208	206	172.09	1.20	1.04	1.37
Tongue/Mouth/Pharynx	141,143-149	2	4.52	0.44	0.05	1.60
Esophagus	150	4	3.87	1.03	0.28	2.59
Stomach	151	20	16.50	1.21	0.74	1.87
Large Intestine and Rectum	153,154	24	21.61	1.11	0.71	1.65
Liver	155.0,155.1	1	0.24	4.20	0.11	23.35
Pancreas	157	15	10.26	1.46	0.82	2.41
Digestive Tract	150-159	59	55.56	1.24	0.97	1.57
Trachea/Bron/Lung	162-163	65	49.16	1.32	1.02	1.68
Breast	174,175	0	0.00	0.00	.	.
Prostate	185	18	16.88	1.07	0.63	1.68
Kidney	189.0/.1/.2	5	5.35	0.93	0.30	2.15
Bladder	188	8	5.21	1.53	0.66	3.00
Brain	191	3	5.09	0.59	0.12	1.67
Lymphoid	200-203	14	9.94	1.41	0.77	2.36
Leukemias	204-206	8	8.87	0.90	0.39	1.76

Cancer of Trachea/Bronchus/Lung and Other includes 162-163, 164.2/.3/.8/.9, 165

Leukemias includes 204-206, 207.0/.2/.8, 208

TABLE 4

MORTALITY IN FLIN FLON 1959 - 83

FEMALES: ALL AGES

		NUMBER OF DEATHS			95% CONFIDENCE	
Cause of Death	**Code**	**Observed**	**Expected**	**S.M.R.**	**LL**	**UL**
All Causes	001-999	523	493.19	1.06	0.97	1.16
Diabetes Mellitus	250	13	8.65	1.50	0.80	2.56
Circulatory Diseases	390-459	190	202.37	0.94	0.81	1.08
Major Cardiovascular	390-448	187	198.00	0.94	0.81	1.09
Ischemic Heart Dis.	410-414	100	104.50	0.96	0.78	1.16
Cerebrovascular	430-438	49	50.86	0.96	0.71	1.27
Rheumatic Fever/Heart	460-519	8	6.72	1.19	0.51	2.33
Respiratory Disease	460-519	55	36.18	1.52	1.15	1.98
COPD	490-493,496	10	6.49	1.54	0.74	2.82
Ulcers	531-534	1	2.37	0.42	0.01	2.34
Cirrhosis of Liver	571	6	5.21	1.15	0.42	2.48
Kidney Diseases	580-593	9	6.31	1.43	0.65	2.69
Congenital Anomalies	740-759	8	9.74	0.82	0.36	1.61
Accidents/Violence	800-999	32	38.73	0.83	0.57	1.17
MVTA	810-819	11	11.58	0.95	0.47	1.69
Accidental Falls	880-888	2	5.55	0.36	0.04	1.30
Accidents: Fires	890-899	5	4.25	1.18	0.38	2.70
Accidental Drowning	910	0	0.00	0.00	.	.
Suicide	950-959	11	6.26	1.76	0.88	3.13
Homicide	960-969	0	0.00	0.00	.	.

COPD = Chronic Obstructive Pulumonary Disease

MVTA = Motor Vehicle Traffic Accidents.

TABLE 5

MORTALITY IN FLIN FLON 1959 - 83

FEMALES: ALL AGES

CAUSE OF DEATH		NUMBER OF DEATHS			95% CONFIDENCE	
Cancer	**Code**	**Observed**	**Expected**	**S.M.R.**	**LL**	**UL**
All Sites	140-208	122	123.02	0.99	0.82	1.18
Tongue/Mouth/Pharynx	141,143-149	2	0.41	4.93	0.60	17.80
Esophagus	150	1	0.37	2.70	0.07	15.01
Stomach	151	5	8.94	0.56	0.18	1.28
Large Intestine and Rectum	153,154	23	19.51	1.18	0.75	1.77
Liver	155.0,155.1	0	0.00	0.00	.	.
Pancreas	157	3	6.90	0.43	0.09	1.23
Digestive Tract	150-159	33	37.36	0.88	0.61	1.24
Trachea/Bron/Lung	162-163	14	10.71	1.31	0.72	2.19
Breast	174,175	26	26.25	0.99	0.65	1.45
Uterus Incl. Cervix	179-182	6	8.68	0.69	0.25	1.49
Ovary	183.0	9	8.84	1.02	0.47	1.92
Kidney	189.0/.1/.2	2	2.51	0.80	0.10	2.88
Bladder	188	3	0.86	3.49	0.70	9.89
Brain	191	4	4.32	0.93	0.25	2.32
Lymphoid	200-203	5	6.84	0.73	0.24	1.68
Leukemias	204-206	5	4.66	1.07	0.35	2.46

Cancer of Trachea/Bronchus/Lung and Other includes 162-163, 164.2/.3/.8/.9, 165

Leukemias include 204-206, 207.0/.2/.8,208

TABLE 6

SMRs FOR MALES IN SEVEN COMMUNITIES 1959-83

Cause of Death	COMMUNITY						
	FF	CR	DAU	PAS	BR	ST	PLP
All Causes	1.09+	1.05	1.01	1.39+	0.92*	0.85*	1.01
Diabetes Mellitus	0.89	0.00	1.09	1.52	0.86	0.84	1.81+
Circulatory Diseases	1.00	1.11	1.03	1.33+	0.93*	0.92	1.01
Major Cardiovascular	0.99	1.07	1.04	1.34+	0.93*	0.93	1.01
Ischemic Heart Dis.	0.97	1.04	1.03	1.13	0.95	0.91	0.92*
Cerebrovascular	1.12	0.55	0.91	1.90+	0.96	1.03	1.06
Rheumatic Fever/Heart	1.51	0.00	0.52	0.47	1.07	1.86+	0.65
Respiratory Disease	1.19	0.56	0.93	1.75+	1.07	0.70*	1.16+
COPD	1.55+	0.22	1.32+	1.63+	1.42	0.50*	1.06
Ulcers	0.95	0.00	0.85	0.99	0.83	0.54	1.05
Cirrhosis of Liver	0.50	0.68	1.11	2.14+	1.04	0.32*	1.03
Kidney Disease	1.66	4.95	0.97	1.18	0.96	0.91	0.66
Congenital Anomalies	0.66	1.70	1.12	1.64	1.05	1.11	1.03
Accidents/Violence	1.23+	1.17	0.90	1.70+	0.73*	0.73*	1.05
MVTA	1.06	1.92	1.07	1.94+	0.88	0.88	1.16
Accidental Falls	1.28	5.67+	0.90	1.39	0.82	0.64	0.85
Accidents: Fires	1.17	0.00	1.07	1.64	0.50*	0.56	1.90+
Accidental Drowning	1.01	0.00	0.24*	1.02	0.54*	0.68	0.56
Suicide	1.36	0.43	1.26	1.25	0.58*	0.59*	1.00
Homicide	1.41	0.00	0.00	1.29	0.46*	0.29	0.63

FF = Flin Flon
CR = Creighton
DAU = Dauphin
PAS = The Pas
BR = Brandon
ST = Steinbach
PLP = Portage la Praire

+Lower 95% confidence limit > 1.0
*Upper 95% confidence limit < 1.0

TABLE 7

SMRs FOR MALES IN SEVEN COMMUNITIES 1959-83

Cause of Death	COMMUNITY						
Cancer	FF	CR	DAU	PAS	BR	ST	PLP
All Sites	1.20+	1.11	1.03	1.07	0.87*	0.91	0.85*
Tongue	0.44	0.00	1.38	2.34	0.94	0.00	0.30
Esophagus	1.03	0.00	0.62	1.68	0.69	0.21	0.76
Stomach	1.21	0.23	1.24	1.36	0.96	1.47+	0.67*
Large Intestine	1.11	1.20	0.90	1.15	0.88	0.83	0.92
Liver	4.20	0.00	1.98	0.00	0.38	3.11	0.28
Pancreas	1.46	4.48	1.54+	1.17	0.99	1.00	0.65
Dig. Tract	1.24	1.37	1.07	1.34	0.90	1.02	0.76*
Lung	1.32+	1.52	1.11	0.99	0.85*	0.77	0.74*
Breast	0.00	0.00	8.00	0.00	3.56	0.00	0.00
Prostate	1.07	0.69	1.07	1.06	0.88	0.86	1.03
Kidney	0.93	0.00	0.67	1.07	0.54*	1.41	0.92
Bladder	1.53	0.00	0.58	0.63	0.92	0.83	0.99
Brain	0.59	0.00	1.40	1.22	1.08	1.27	0.82
Lymphoid	1.41	0.00	0.82	0.91	0.81	1.07	1.33
Leukemias	0.90	0.00	1.13	0.19	0.90	0.93	1.05

FF = Flin Flon
CR = Creighton
DAU = Dauphin
PAS = The Pas
BR = Brandon
ST = Steinbach
PLP = Portage la Praire

+Lower 95% confidence limit > 1.0
*Upper 95% confidence limit < 1.0

TABLE 8

SMRs FOR FEMALES IN SEVEN COMMUNITIES 1959-83

Cause of Death	COMMUNITY						
	FF	CR	DAU	PAS	BR	ST	PLP
All Causes	1.06	1.05	0.95	1.38+	0.89*	0.86*	1.02
Diabetes Mellitus	1.50	0.00	1.43	1.09	0.75*	0.85	1.29
Circulatory Disease	0.94	0.90	1.05	1.44+	0.86*	0.90*	0.98
Major Cardiovascular	0.94	1.50	1.05	1.46+	0.85*	0.90	0.97
Ischemic Heart Dis.	0.96	0.70	0.99	1.33+	0.89*	0.84*	0.81*
Cerebrovascular	0.96	0.94	1.00	1.43+	0.95	0.95	1.15+
Rheumatic Fever/Heart	1.19	0.00	1.53	0.48	0.89	1.07	0.65
Respiratory Disease	1.52+	0.30	0.82	1.45+	1.07	0.69*	1.30+
COPD	1.54	0.00	0.86	1.54	1.25	0.80	0.98
Ulcers	0.42	0.00	0.92	3.08	0.93	0.43	0.67
Cirrhosis of Liver	1.15	4.87	0.13*	2.48+	0.60*	0.53	0.76
Kidney Disease	1.43	0.00	1.34	1.83	0.88	1.07	1.02
Congenital Anomalies	0.82	1.26	0.72	1.35	1.05	1.31	1.05
Accidents/Violence	0.83	0.82	0.82	1.82+	0.85*	0.63*	1.12
MVTA	0.95	3.21	0.78	1.74	1.14	0.84	1.49+
Accidental Falls	0.36	0.00	0.80	1.00	0.75	1.03	1.04
Accidents: Fires	1.18	0.00	0.42	3.63+	0.59	0.57	0.35*
Accidental Drowning	0.00	21.28	1.44	11.20+	0.50	0.40	1.59
Suicide	1.76	0.00	1.18	2.56+	0.67	0.12*	1.15
Homicide	0.00	0.00	1.01	7.60	0.57	0.00	0.41

FF = Flin Flon
CR = Creighton
DAU = Dauphin
PAS = The Pas
BR = Brandon
ST = Steinbach
PLP = Portage la Praire

+Lower 95% confidence limit $>$ 1.0
*Upper 95% confidence limit $<$ 1.0

TABLE 9

SMRs FOR FEMALES IN SEVEN COMMUNITIES 1959-83

Cause of Death	COMMUNITY						
Cancer	FF	CR	DAU	PAS	BR	ST	PLP
All Sites	0.99	1.06	0.80*	1.04	0.91*	0.96	0.91
Tongue	4.93	0.00	2.78	8.26	0.68	2.36	0.72
Esophagus	2.70	0.00	0.00	4.95	0.48	2.72	0.64
Stomach	0.56	6.71	0.84	0.41	0.77	1.24	0.66
Large Intestine	1.18	0.53	0.66*	1.04	0.96	0.58*	1.04
Liver	0.00	0.00	0.00	0.00	1.79	5.75	2.61
Pancreas	0.43	0.00	0.91	1.28	0.81	1.11	1.19
Dig. Tract	0.88	0.48	0.73*	0.98	0.89	0.92	0.94
Lung	1.31	0.95	0.82	1.00	1.02	0.62	0.78
Breast	0.99	0.21	0.77	1.28	0.89	0.86	0.93
Uterus	0.69	0.00	0.74	1.48	0.99	0.52	1.00
Ovary	1.02	5.36	0.85	0.81	0.86	0.72	0.87
Kidney	0.80	0.00	0.58	0.00	1.20	1.46	0.77
Bladder	3.49	0.00	0.54	0.00	0.67	1.78	1.06
Brain	0.93	0.00	1.22	2.96	1.36	1.27	1.29
Lymphoid	0.73	9.90+	0.96	0.19	0.80	1.07	0.82
Leukemias	1.07	8.00	1.15	1.60	0.89	1.39	0.80

FF = Flin Flon
CR = Creighton
DAU = Dauphin
PAS = The Pas
BR = Brandon
ST = Steinbach
PLP = Portage la Praire

+Lower 95% confidence limit $>$ 1.0
*Upper 95% confidence limit $<$ 1.0

Figure 1

CANCER OF TRACHEA, BRONCHUS, LUNG

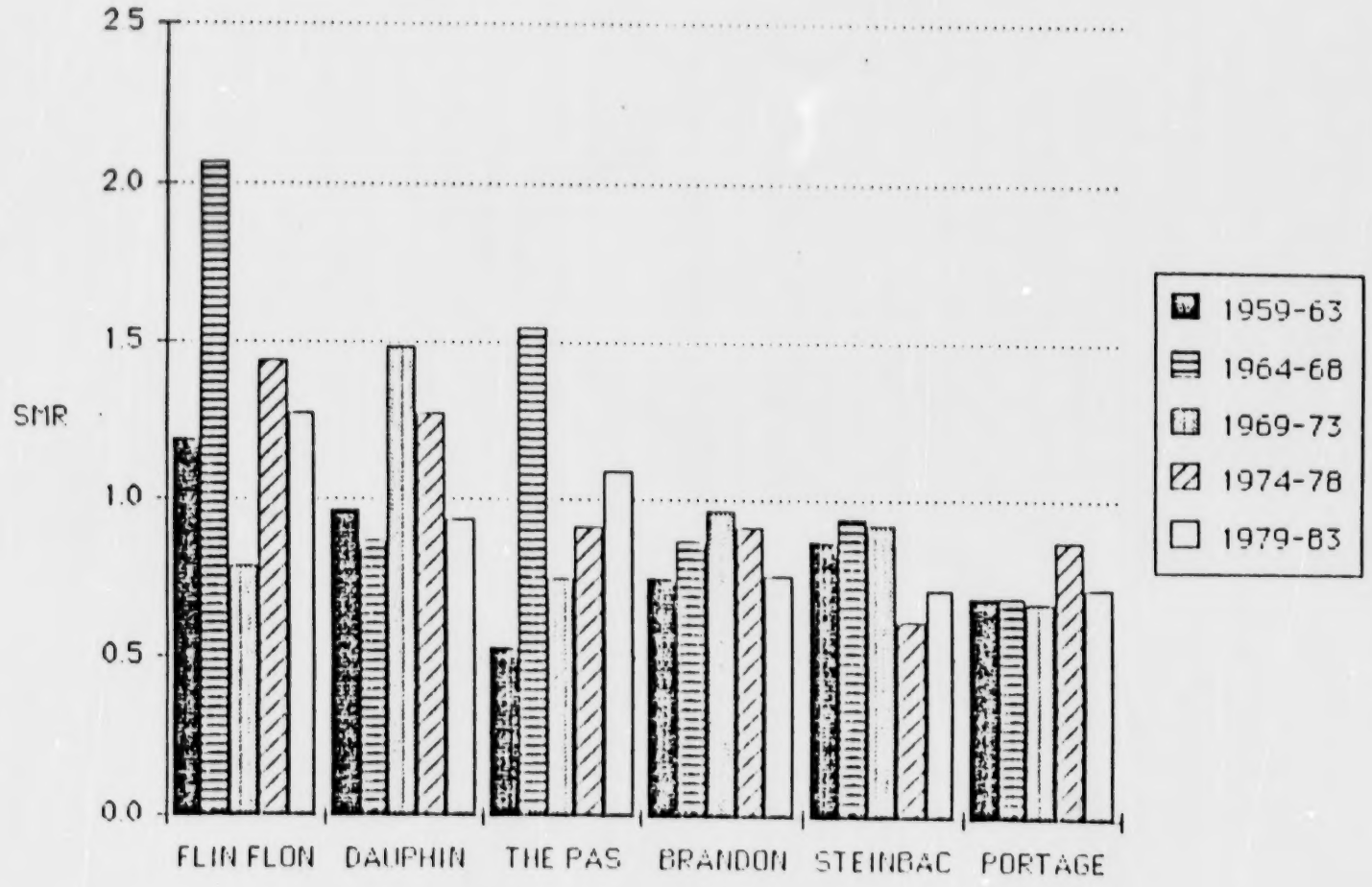


Figure 2

CANCERS OF DIGESTIVE TRACT - MALES

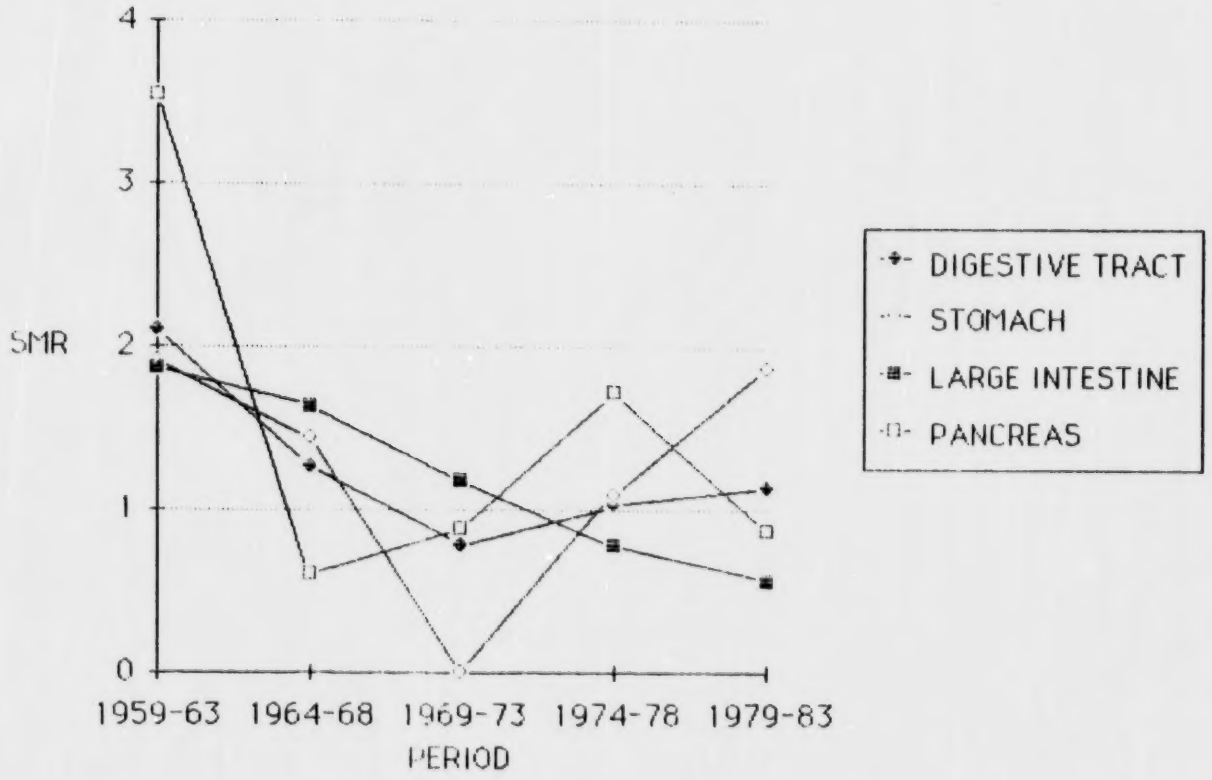
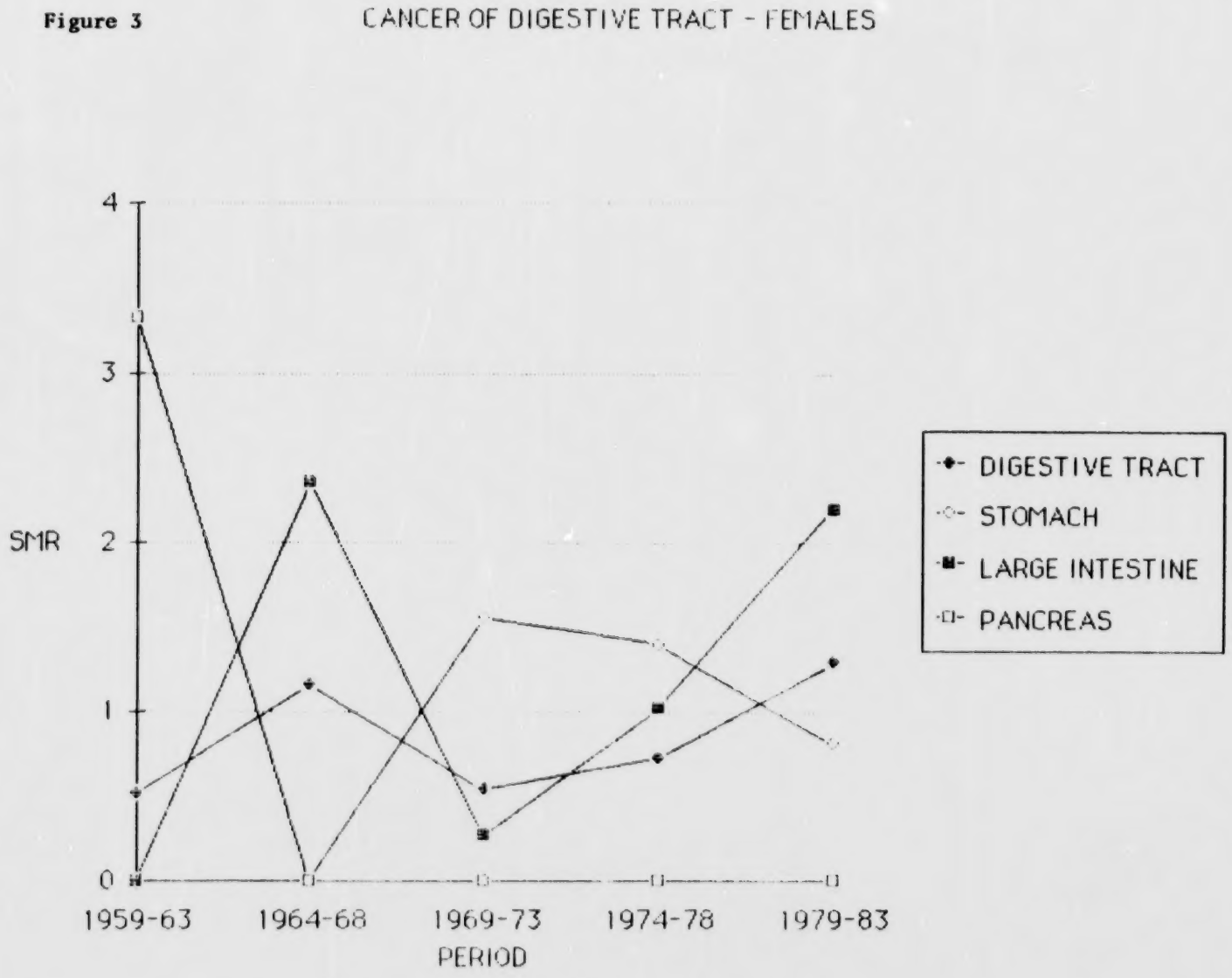


Figure 3


CANCER OF DIGESTIVE TRACT - FEMALES
SMR
4
3
2
1
0
1959-63
1964-68
1969-73
1974-78
1979-83
PERIOD
DIGESTIVE TRACT
STOMACH
LARGE INTESTINE
PANCREAS

CHAPTER V

MORBIDITY IN FLIN FLON

TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHODS	1
RESULTS	1
DISCUSSION AND CONCLUSION	3
TABLES	

INTRODUCTION

The Manitoba Health Services Commission (MHSC) administers the Manitoba Health Insurance Plan. Virtually all health services used by residents of the province are recorded and paid for by the MHSC. The exception is services covered by the Workers Compensation Board (WCB). Since the reason (diagnosis) for using health services is coded as well on physicians' claims for payment, these could be used for determining the period prevalence of diseases or groups of diseases for the Manitoba population.

MHSC records were used to determine the period prevalence of groups of diseases for the residents of Flin Flon as well as for the province as a whole. The aim of this investigation was to determine if health services for any of the broad disease categories were used by a larger proportion of Flin Flon residents than by the general provincial population.

METHODS

MHSC reports on the utilization of medical services by Manitoba residents by age group and diagnostic category for five fiscal years between April 1, 1980 and March 31, 1985 were reviewed. These reports were made available by MHSC for the city of Flin Flon (Municipality #190) and for the province. Reports provide information for six age groups (0 - 4, 5 - 14, 15 - 29, 30 - 64, 65+ and total) and for 17 diagnostic categories. For each age group and diagnostic category, the number of discrete patients, the number of services and the number of patients per 1,000 population (utilization rate) were given. The number of discrete patients is an unduplicated count of individuals using services in each group for each diagnostic category. This means that an individual can only be counted once for each diagnostic category within any fiscal year. The utilization rate is an estimate of the period prevalence.

The ratio between the utilization rate for Flin Flon and the province was calculated. If the ratio equalled 1, the rate per 1,000 in Flin Flon and in the province would be the same. If the ratio was less then 1, then fewer individuals per 1,000 population used services in Flin Flon than in the province. If the ratio was greater than 1, more individuals per 1,000 population in Flin Flon used services than in the province.

RESULTS

Results of this investigation are presented in Tables 1 through 15:

Table 1: Infectious and Parasitic Diseases (ICD* 001 - 139)

---

* International Classification of Diseases (9th Revision) three digit codes.

Table 2: Neoplasms (140 - 239)
Table 3: Endocrine, Metabolic and Immunity Disorders (240 - 279)
Table 4: Diseases of Blood and Blood-forming Organs (280 - 289)
Table 5: Mental Disorders (290 - 319)
Table 6: Diseases of Nervous System and Sense Organs (320 - 389)
Table 7: Diseases of Circulatory System (390 - 459)
Table 8: Diseases of Respiratory System (460 - 519)
Table 9: Diseases of Digestive System (520 - 579)
Table 10: Diseases of Genitourinary System (580 - 629)
Table 11: Diseases of Skin and Subcutaneous Tissue(680 - 709)
Table 12: Diseases of Musculoskeletal System and Connective Tissue (710 - 739)
Table 13: Congenital Anomalies (740 - 759)
Table 14: Symptoms, Signs, Ill-defined Conditions (780 - 799)
Table 15: Injuries and Poisonings (E800 - E999)

Each table presents utilization of medical services for five years (1980/81, 1981/82, 1982/83, 1983/84 and 1984/85) by age and diagnostic category. The number of discrete patients is given for each age group. In addition, the ratio between the utilization rate for Flin Flon and Manitoba is also shown.

On the basis of these ratios, diagnostic categories were divided into three groups:

Group 1: diagnostic categories for which the utilization rate of medical services by residents of Flin Flon was less than the provincial rate. The Flin Flon-Manitoba ratio was less than 0.9 for the majority of age groups and years. The diagnostic categories in this group are:

Endocrine, Metabolic Diseases and Immunity Disorders (Table 3)
Diseases of Blood and Blood-forming Organs (Table 4)
Mental Disorders (Table 5)

Group 2: diagnostic categories for which the utilization rates of medical services by residents of Flin Flon and of the province were similar. This group comprises the following diagnostic categories for which the ratio of Flin Flon to Manitoba varied between 0.9 and 1.1.:

Infectious and Parasitic Diseases (Table 1)
Neoplasms (Table 2)
Diseases of Nervous System and Sense Organs (Table 6)
Diseases of Circulatory System (Table 7)
Diseases of Genitourinary System for age groups 5+ (Table 10)
Diseases of Skin and Subcutaneous Tissue (Table 11)
Congenital Anomalies of age groups 5+ (Table 13)

Group 3: diagnostic categories for which utilization of medical services by Flin Flon residents was higher than the provincial rate (ie. the Flin Flon-Manitoba ratio was greater than 1.1 in most age groups and years). The following diagnostic categories are included in this group:

Diseases of Respiratory System (Table 8)
Diseases of Digestive System (Table 9)
Diseases of Genitourinary System for Age Group 0-4 (Table 14)

Diseases of Musculoskeletal System and Connective Tissue (Table 12)
Congenital Anomalies for Age Group 0 - 4 (Table 13)
Ill-defined Conditions, Symptoms and Signs (Table 14)
Injuries and Poisonings (Table 15)

DISCUSSION AND CONCLUSION

The comparison of Flin Flon utilization rates with those for the province suggests higher morbidity in all age groups in Flin Flon due to diseases of respiratory, digestive and musculoskeletal system including connective tissue as well as injuries and poisonings. In addition, in the age group 0 - 4 the morbidity due to disease of the genitourinary system and congenital anomalies was higher in Flin Flon.

The higher utilization rates are not necessarily caused by an increased incidence of disease. They could also be due to longer care and more frequent use of medical services.

TABLE I

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Infection and Parasitic Disease (001 - 139)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	49	0.6	67	0.7	78	0.8	82	0.9	70	0.7
5-14	102	0.7	119	0.9	148	1.1	137	0.9	168	1.1
15-29	216	0.9	233	1.0	236	1.0	232	1.0	227	1.0
30-64	133	0.8	150	0.9	152	0.9	139	0.8	170	0.9
65 +	29	0.8	31	0.8	29	0.8	25	0.5	34	0.8
TOTAL	529	0.8	600	0.9	643	1.0	615	0.9	669	1.0

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 2

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Neoplasms (140 - 239)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	3	0.6	8	1.6	6	1.1	5	1.0	5	1.0
5-14	6	0.8	10	1.1	9	1.0	6	0.7	6	0.7
15-29	28	0.7	35	0.9	38	0.9	53	1.3	44	1.1
30-64	102	0.8	149	1.2	143	1.1	126	1.0	118	0.9
65 +	77	1.0	77	0.9	96	1.1	88	0.9	67	0.7
TOTAL	216	0.8	279	1.0	292	1.0	278	0.9	240	0.8

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 3

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Endocrine, Metabolic Disease and Immunity Disorders (240 - 279)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	4	0.5	3	0.3	4	0.4	7	0.8	7	0.8
5-14	5	0.3	10	0.5	13	0.7	9	0.5	10	0.6
15-29	83	0.8	93	0.9	117	1.2	127	1.4	89	1.1
30-64	162	0.6	205	0.8	199	0.8	232	0.9	231	0.9
65 +	77	0.7	94	0.8	109	0.9	109	0.8	109	0.8
TOTAL	331	0.6	405	0.8	442	0.8	484	0.9	446	0.8

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 4

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Diseases of Blood and Blood Forming Organs (280 - 289)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	11	0.5	14	0.6	10	0.5	15	0.8	12	0.8
5-14	8	0.3	18	0.7	22	0.9	20	0.9	28	1.3
15-29	16	0.4	26	0.6	20	0.5	36	1.0	24	0.7
30-64	31	0.5	39	0.7	48	0.8	43	0.8	51	0.9
65 +	23	0.6	29	0.7	24	0.6	29	0.7	25	0.5
TOTAL	89	0.5	126	0.7	124	0.7	143	0.8	140	0.8

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 5

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Mental Disorders (290 - 319)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	11	0.9	5	0.4	10	0.8	10	0.8	6	0.6
5-14	14	0.5	10	0.4	24	0.8	25	0.8	22	0.8
15-29	119	0.6	159	0.8	149	0.8	163	0.9	162	1.0
30-64	289	0.8	317	0.9	290	0.8	340	1.0	320	0.9
65 +	89	0.9	108	1.0	136	1.2	142	1.2	142	1.2
TOTAL	522	0.7	599	0.8	609	0.8	680	0.9	652	0.9

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 6

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Diseases of Nervous System and Sense Organs (320 - 389)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	175	0.9	224	1.0	218	1.0	264	1.2	225	0.9
5-14	520	0.8	542	1.2	567	1.2	640	1.3	517	1.1
15-29	819	1.0	866	1.1	804	1.0	806	1.1	718	1.0
30-64	1058	1.0	1117	1.1	1078	1.0	1177	1.1	1096	1.1
65 +	381	1.0	393	1.0	464	1.1	454	1.0	459	1.0
TOTAL	2953	1.0	3142	1.1	3131	1.1	3341	1.1	3015	1.0

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 7

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Diseases of Circulatory System (390 - 459)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	2	0.5	8	1.6	4	0.9	6	1.3	4	0.9
5-14	6	0.8	8	1.0	13	2.0	10	1.6	6	1.0
15-29	60	0.9	69	1.0	70	1.0	70	1.1	82	1.4
30-64	396	0.9	434	1.0	434	0.9	442	1.0	426	1.0
65 +	325	0.8	372	0.8	400	0.9	397	0.9	403	0.9
TOTAL	789	0.8	891	0.8	921	0.9	925	0.9	921	0.9

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 9

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Diseases of Respiratory System (460 - 519)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	341	1.1	377	1.1	438	1.5	424	1.3	376	1.1
5-14	410	0.9	456	1.1	630	1.4	593	1.3	524	1.1
15-29	818	1.2	900	1.3	962	1.5	938	1.4	877	1.4
30-64	666	0.9	749	1.1	885	1.2	931	1.3	933	1.2
65 +	219	1.0	257	1.2	302	1.2	281	1.2	317	1.3
TOTAL	2454	1.0	2739	1.2	3217	1.3	3167	1.3	3027	1.2

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 9

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Diseases of Digestive System (520 - 579)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	116	1.0	150	1.1	138	1.1	186	1.4	161	1.2
5-14	61	0.6	93	1.2	97	1.3	117	1.4	126	1.5
15-29	302	1.2	406	1.5	422	1.6	441	1.8	426	1.8
30-64	379	1.0	467	1.2	455	1.2	515	1.4	517	1.4
65 +	167	1.0	216	1.3	228	1.3	221	1.4	217	1.2
TOTAL	1025	1.0	1332	1.3	1340	1.3	1480	1.5	1447	1.4

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE IO

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Disease of Genitourinary System (580 - 629)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	49	1.6	48	1.4	49	1.4	65	1.9	47	1.4
5-14	34	0.7	50	1.0	49	1.0	60	1.2	56	1.2
15-29	466	0.9	575	1.1	559	1.1	533	1.1	513	1.1
30-64	410	0.8	489	0.9	498	0.9	520	1.0	540	1.0
65 +	102	0.8	136	1.0	132	1.0	137	1.0	138	1.0
TOTAL	1061	0.9	1298	1.0	1287	1.0	1315	1.1	1294	1.1

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 11

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Diseases of Skin and Subcutaneous Tissue (680 - 709)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	121	1.0	155	1.1	172	1.3	169	1.2	170	1.2
5-14	112	0.7	151	1.0	155	1.0	192	1.2	189	1.2
15-29	347	0.8	416	0.9	458	1.1	446	1.0	467	1.2
30-64	307	0.8	423	1.1	416	1.0	456	1.1	430	1.1
65 +	121	1.0	152	1.1	152	1.1	168	1.2	154	1.0
TOTAL	1008	0.8	1297	1.0	1353	1.1	1431	1.1	1410	1.1

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 12

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Disease of Musculo-Skeleta System & Connective Tissue (710 - 739)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	14	0.8	21	1.2	19	1.3	19	1.3	25	1.6
5-14	64	0.9	70	1.0	80	1.1	106	1.4	86	1.2
15-29	311	1.0	397	1.2	403	1.3	415	1.4	398	1.3
30-64	576	1.0	638	1.1	675	1.2	749	1.3	721	1.2
65 +	224	1.0	277	1.1	293	1.1	304	1.2	297	1.1
TOTAL	1189	1.0	1403	1.1	1470	1.2	1593	1.2	1527	1.2

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 13

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Congenital Anomalies (740 - 759)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	47	1.0	57	1.1	57	1.2	58	1.3	57	1.3
5-14	21	0.9	17	0.7	21	0.9	31	1.1	24	0.9
15-29	18	0.9	10	0.6	18	1.0	21	1.1	17	1.0
30-64	15	1.3	3	0.3	10	0.75	9	1.0	7	0.5
65 +	1	0.3	3	0.8	3	1.0	4	1.7	1	0.3
TOTAL	102	1.1	90	0.8	109	1.1	123	1.2	106	1.1

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 14

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Symptoms, Signs, Ill-defined Conditions (780 - 799)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	158	1.0	193	1.1	182	1.1	196	1.2	188	1.1
5-14	200	0.9	221	1.0	279	1.3	284	1.3	298	1.4
15-29	508	1.1	600	1.2	584	1.3	598	1.3	595	1.4
30-64	597	0.9	778	1.2	739	1.1	750	1.1	829	1.1
65 +	294	1.1	336	1.2	351	1.2	347	1.2	406	1.4
TOTAL	1757	1.0	2128	1.2	2135	1.2	2175	1.2	2317	1.3

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

TABLE 15

UTILIZATION OF MEDICAL SERVICES BY
RESIDENTS OF FLIN FLON

DIAGNOSTIC CATEGORY: Injury and Poisonings (E800 - E999)

	1980 - 81*		1981 - 1982		1982 - 83		1983 - 84		1984 - 85	
AGE	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***	Patients No.**	FF/MB Ratio***
0-4	138	1.3	193	1.4	199	1.7	195	1.7	172	1.5
5-14	337	1.3	401	1.5	435	1.6	417	1.6	426	1.6
15-29	817	1.2	881	1.3	887	1.4	854	1.4	818	1.4
30-64	581	1.0	682	1.3	686	1.3	747	1.3	739	1.3
65 +	156	1.1	189	1.3	203	1.3	206	1.3	185	1.2
TOTAL	2029	1.2	2327	1.3	2410	1.4	2419	1.4	2340	1.4

* Between April 1, 1980 and March 31, 1981

** Number of discrete patients: unduplicated count for each diagnostic category in each age group.

*** Ratio between the utilization rate (number of patients per 1,000 population) for Flin Flon (FF) and Manitoba (MB).

10/12/85
Unpublished Report

CHAPTER VI

MAPPING OF CANCER INCIDENCE IN MANITOBA BY GEOGRAPHIC LOCALE: RESULTS FOR FLIN FLON

SUBMITTED BY DEPARTMENT OF EPIDEMIOLOGY AND BIOSTATISTICS, MANITOBA CANCER TREATMENT AND RESEARCH FOUNDATION

Late in 1983, the Department of Epidemiology and Biostatistics initiated systematic investigations into the distribution of specific cancer sites in Manitoba over time and geographic locales in order to discover any unusual trends and patterns of incidence of such cancers.

Cancer incidence for the time periods 1965-69, 1970-74, and 1975-79 has been tabulated for the 20 census divisions of the province which were in effect in the Cancer Registry prior to 1982. The time period of 1965-79 was considered because of the accuracy and completeness of case ascertainment.

The method applied is a standard approach comparing the observed number of cases to the expected ones, i.e. observed/expected (relative risk ratios), based on standard age-sex specific rates for the three time periods of the Manitoba population. Hence, the ratios computed for geographic locales in Manitoba are compared to the Manitoba experience as a whole.

Cancer incidence for the selected time periods were tabulated for the 20 census divisions. More specifically municipalities and towns, like Flin Flon, were further broken down by cancer site, sex, and age.

Although incidence mapping is more reliable than mortality mapping in the comparison of cancer risks by geographic locale, adverse effects of population mobility on such investigations cannot be totally overcome. Hence, interpretation of the analyses should be made with caution.

The small excess of 1.00 in a risk ratio may be due to bias. This bias can come about not only through selective migration by people who are not well but by the fact that addresses given do not precisely indicate where the patient has been living and possibly by differences in the completeness of case ascertainment. One may find such bias more in some sites than in others. Random variation in incidence must also be taken into account when one examines the relative risk. The significant relative risk ratios are indicated by asterisk(*) in the attached table for the town of Flin Flon.

INTERNATIONAL CLASSIFICATION OF DISEASES

(9TH REVISION)

140	lip
141	tongue
142	major salivary glands
143	gum
144	floor of mouth
145	unspecified parts of mouth
146	oropharynx
147	nasopharynx
148	hypopharynx
149	ill-defined sites within the lip, oral cavity and pharynx
150	esophagus
151	stomach
152	small intestine, including duodenum
153	colon
154	rectum, rectosigmoid junction and anus
155	liver and intrahepatic bile ducts
156	gallbladder and extrahepatic bile ducts
157	pancreas
158	retroperitoneum and peritoneum
159	ill-defined sites within digestive organs and peritoneum
160	nasal cavities, middle ear and sinuses
161	larynx
162	trachea, bronchus and lung
163	pleura
164	thymus, heart and mediastinum
165	ill-defined sites within the respiratory system
170	bone and articular cartilage
171	connective tissue and other soft tissue
172	melanoma of skin
173	other malignant neoplasm of skin
174	breast (female)
175	breast (male)
179	uterus (part unspecified)
180	cervix uteri
181	placenta
182	body of uterus
183	ovary and other uterin adnexa
184	other and unspecified female genital organs
185	prostate
186	testis
187	penis and other male genital organs
188	bladder
189	kidney and other unspecified urinary ograns
190	eye

191	brain
192	other and unspecified parts of nervous system
193	thyroid gland
194	other endocrine glands and related structures
195	other and ill-defined sites
196	secondary and unspecified malignant neoplasm of lymph nodes
197	secondary malignant neoplasm of respiratory and digestive systems
198	secondary malignant neoplasm of other specified sites
199	without specification of site
200	lymphosarcoma and reticulosarcoma
201	Hodgkin's disease
202	lymphoid and histiocytic tissue
203	multiple myeloma and immunoproliferative neoplasms
204	lymphoid leukemia
205	myeloid leukemia
206	monocytic leukemia
207	other specified leukemia
208	leukemia of unspecified cell type
238.4	polycythemia vera
289.8	other specified diseases of blood and blood-forming organs
233.1	cervix (in situ)

FLIN FLON

ICD9		1965-69			1970-74			1975-79			TOTAL
		O	E	O/E	O	E	O/E	O	E	O/E	O/E
140	M	0	2.771	-	3	2.868	1.05	4	2.203	1.82	0.89
	F	0	0.236	-	0	0.148	-	0	0.136	-	-
141	M	0	0.352	-	1	0.328	3.05	0	0.327	-	0.99
	F	0	0.130	-	2	0.215	9.30 *	0	0.182	-	3.80
142	M	0	0.487	-	0	0.218	-	1	0.145	6.90	1.18
	F	0	0.573	-	0	0.252	-	1	0.068	14.71	1.12
143-5	M	0	0.906	-	0	0.581	-	0	0.509	-	-
	F	0	0.389	-	0	0.222	-	0	0.374	-	-
146	M	0			0	0.122	-	0	0.284	-	-
	F	0			0	0.048	-	0	0.048	-	-
147	M	0			0	0.123	-	0	0.124	-	-
	F	0			0	0.025	-	0	0.085	-	-
148	M	0			0	0.060	-	0	0.169	-	-
	F	0			0	0.036	-	0	0.026	-	-
149	M	0			0			0			
	F	0			0			0			
150	M	1	0.748	1.35	1	0.913	1.10	1	0.977	1.02	1.14
	F	0	0.290	-	0	0.321	-	0	0.359	-	-
151	M	0	4.926	- *	2	3.933	0.51	6	3.350	1.79	0.66
	F	0	2.056	-	2	1.740	1.15	1	1.863	0.54	0.53
152	M	0	0.215	-	0	1.65	-	0	0.290	-	-
	F	0	0.224	-	0	0.137	-	0	0.216	-	-
153	M	0	4.743	- *	8	5.175	1.55	7	6.400	1.09	0.92
	F	1	4.545	0.22 *	6	4.930	1.22	9	6.159	1.46	1.02
154	M	2	2.684	0.75	3	3.584	0.84	2	3.403	0.59	0.72
	F	0	1.718	-	0	2.179	-	2	2.527	0.79	0.31

ICD9		1965-69			1970-74			1975-79			TOTAL
		O	E	O/E	O	E	O/E	O	E	O/E	O/E
155	M	0	0.271	-	0	0.377	-	1	0.383	2.61	0.97
	F	0	0.204	-	0	0.284	0	0	0.204	-	-
156	M	0	0.481	-	2	0.577	3.47	0	0.460	-	1.32
	F	0	0.581	-	1	0.528	1.59	0	0.518	-	0.55
157	M	0	1.813	-	3	2.132	1.41	3	2.297	1.31	0.96
	F	0	0.995	-	0	1.510	-	0	1.738	-	- *
160	M	0	0.187	-	0	0.099	-	0	0.150	-	-
	F	0	0.134	-	0	0.101	-	0	0.092	-	-
161	M	1	1.182	0.85	5	0.968	5.17 *	0	1.016	-	1.90
	F	0	0.138	-	0	0.119	-	2	0.163	12.27 *	4.76
162	M	3	9.446	0.32 *	10	11.117	0.90	24	13.068	1.84 *	1.10
	F	0	1.580	-	3	1.983	1.51	5	3.276	1.53	1.17
163-5	M	0			0			0			
	F	0			0			0			
175	M	1	0.194	5.15	0	0.159	-	0	0.160	-	1.95
174	F	11	13.545	0.81	18	15.409	1.17	19	16.722	1.14	1.05
180	F	1	6.083	0.16 *	1	4.041	0.25	8	3.183	2.51 *	0.75
179-82	F	2	3.589	0.56	0	3.672	- *	0	4.739	- *	0.17 *
183	F	0	3.232	- *	3	2.721	1.10	3	2.605	1.15	0.70
184	F	0	0.394	-	1	0.459	2.18	0	0.528	-	0.72
185	M	0	6.252	- *	15	9.354	1.60 *	10	11.564	0.86	0.92
186	M	0	0.614	-	0	0.619	-	1	0.751	1.33	0.50
187	M	0	0.157	-	0	0.074	-	0	0.190	-	-
188	M	0	3.146	- *	6	3.722	1.61	5	3.898	1.28	1.02
	F	0	0.749	-	1	1.054	0.95	2	1.280	1.56	0.97

ICD9		1965-69			1970-74			1975-79			TOTAL
		O	E	O/E	O	E	O/E	O	E	O/E	O/E
189	M	0	1.952	-	1	2.180	0.46	4	2.037	1.96	0.81
	F	0	0.907	-	2	0.955	2.09	0	1.192	-	0.65
172	M	0	0.497	-	0	0.615	-	1	0.623	1.61	0.58
	F	0	0.575	-	1	0.745	1.34	0	1.005	-	0.43
173	M	4	3.706	0.46	12	13.448	0.89	22	18.896	1.16	0.93
	F	4	5.166	0.77	10	9.386	1.07	9	12.784	0.70	0.84
190	M	1	0.286	3.50	0	0.377	-	0	0.293	-	1.05
	F	0	0.129	-	0	0.191	-	0	0.217	-	-
191-2	M	0	2.123	-	2	1.708	1.17	1	1.321	0.76	0.58
	F	0	1.660	-	1	1.215	0.82	2	1.007	1.99	0.77
193	M	0	0.417	-	0	0.225		1	0.377	2.65	0.98
	F	1	0.734	1.36	1	0.695	1.44	2	0.849	2.36	1.76
194	M	0	0.309	-	0	0.212	-	0	0.110	-	-
	F	0	0.280	-	0	0.158	-	0	0.068	-	-
170	M	0	0.300	-	0	0.171	-	0	0.173	-	-
	F	0	0.207	-	0	0.197	-	0	0.171	-	-
171	M	0	0.506	-	0	0.742	-	1	0.501	2.00	0.57
	F	0	0.434	-	1	0.412	2.43	1	0.317	3.15	1.72
195-9	M	0			3			3			
	F	0			0			1			
200	M	1	1.163	0.86	3	1.617	1.86	1	0.924	1.08	1.35
	F	0	0.719	-	1	0.848	1.18	1	0.641	1.56	0.91
201	M	0	0.735	-	0	0.702	-	0	0.635	-	-
	F	0	0.580	-	1	0.534	1.87	0	0.383	-	0.67
202	M	0			0	0.506	-	0	1.291	-	-
	F	0			1	0.520	1.92	1	1.092	0.92	1.24
203	M	0	0.762	-	0	0.984	-	0	0.885	-	-
	F	0	0.409	-	0	0.627	-	2	0.614	3.26	1.21

ICD9		1965-69			1970-74			1975-79			TOTAL
		O	E	O/E	O	E	O/E	O	E	O/E	O/E
204-7	M	0	2.324	-	3	2.443	1.23	2	2.720	0.74	0.67
	F	0	1.258	-	2	1.538	1.30	2	1.285	1.56	0.98
238.4	M	1			1	0.526	1.90	0	0.218	-	1.34
	F	0			0	0.212	-	0	0.141	-	-
289.8	M	0			1	0.116	8.62	0	0.111	-	4.41
	F	0			0	0.056	-	0	0.046	-	-
233.1+	F	7			16			27			
TOTAL	M	15	61.655	0.24 *	85	73.840	1.15	101	83.233	1.21 *	0.92
	F	20	54.584	0.37 *	59	60.523	0.97	73	69.003	1.06	0.83 *

+ Cervix in situ (no rates) for info only.

* p .05

ICD - International Classification of Disease (9th Revision)

O - Observed

E - Expected

O/E - Observed over Expected Ratio

CHAPTER VII

OCCUPATIONAL LUNG DISEASE SURVEILLANCE

TABLE OF CONTENTS

	Page
INTRODUCTION	1
RESULTS	1
DISCUSSION	3
TABLES	

INTRODUCTION

The Manitoba Regulation 209/77 provides for medical examination of workers in prescribed occupations. A prescribed occupation is an occupation in which the worker is exposed for at least fifty hours each month to the inhalation of any substance that may produce fibrosis of the lungs in the following industries:

(1) hard rock mining,
(2) stone cutting,
(3) metal foundry work,
(4) hard rock drilling and crushing,
(5) any industry in which workers are exposed to dust in use of abrasive equipment and where the abrasive, or the object being abraded, contains silica on its surface or in its interior,
(6) any industry in which asbestos, or any mixture of asbestos, is worked or handled, or any asbestos textiles, or any article composed of or containing asbestos, is manufactured or repaired.

The Sanatorium Board of Manitoba is operating the program, "Occupational Lung Disease Surveillance", to comply with the Regulation 209/77. Specialists from the Departments of Radiology and Medicine of the University of Manitoba are responsible for the quality assurance of the program as well as for the interpretation of chest radiographs and lung function tests. Until 1983, most production workers of the HBM&S were examined once a year by chest radiography and spirometry. A questionnaire was also administered annually. Since 1983, workers attend examinations once every five years until their 35th birthday and annually thereafter.

RESULTS

Surveys of HBM&S workers conducted between 1976 and 1983 were examined to determine the prevalence of radiographic abnormalities consistent with fibrosis (pneumoconiosis), prevalence of obstructive pattern of pulmonary function, and the distribution of smoking habits. Results are tabulated in the Tables 1 - 3. In 1983, only individuals older than 34 years were tested hence the total number of examined subjects was smaller than in the preceding years.

Between 1976 and 1983, 3,724 workers of HBM&S were examined either in Flin Flon or in Snow Lake. The number of examinations experienced by a worker ranged from 1 to 7 examinations in the time period depending on duration of employment. No more than 1 examination per year would have been conducted on an individual worker. Radiographic abnormalities which were suspect of pneumoconiosis (silicosis or asbestosis) were diagnosed in 25 or 6.7 per 1,000 subjects.

Table 1 shows the distribution of HBM&S employees by the percent predicted value of FEV_1 (forced expiratory volume in one second). Using the prediction equations, derived from a provincial sample of asymptomatic non-smokers, the measured (observed) value of FEV_1 is

expressed as percent of the predicted value for a subject of the same sex, height and age. The percent predicted values which are higher than 80 percent are usually considered to be within normal (expected) limits. Values which are lower than 80 percent are indicative of airflow obstruction: the lower the value, the greater the obstruction.

It can be seen in Table 1 that the lung function of 75 to 80 percent of examined subjects was within the normal limits (i.e. FEV_1 was greater than 80% predicted). On the other hand, 20 to 25 percent of subjects were found to have an obstructive pattern of lung function. On each survey, about 6 percent of subjects were found to have a moderate to severe degree of obstruction (i.e. FEV_1 less than 65% predicted).

In Table 2, subjects tested on each survey are displayed by the value of the ratio between FEV_1 and FVC (forced vital capacity). This parameter of lung function is also an indicator of airflow obstruction. Unlike percent predicted values, the FEV_1/FVC ratio is age dependent. Although it decreases with age, it is not expected to be lower than 65 percent in asymptomatic non-smokers younger than 55 years. Results in Table 2 are consistent with the distrubution of FEV_1 percent predicted values in Table 1. Tables 1 and 2 indicate that obstructive pattern of lung function is a common disorder in the work force of HBM&S.

On surveys, smoking habits were obtained by questionnaires. Smokers were definded as subjects who at the time of the survey, smoked at least one cigarette, or one pipeful, or one cigar per day on most (at least 5) days of the week. The proportion of subjects who were classified as smokers in each survey is shown by age in Table 3. It should be noted that approximately 50 percent of all examined subjects were smokers. However, this proportion varied by age. Among those younger than 40 years, the proportion of smokers varied between 50 to 60 percent. Among those older than 60 years, there were between 24 to 37 percent of smokers.

DISCUSSION

The prevalence of pneumoconioses (silicosis and asbestosis) appears to be low. However, it should be pointed out, that this data reflects findings on survey radiographs and that some cases were subsequently not confirmed by follow-up examination. In addition, the burden of pneumoconioses might be somewhat underestimated by this data. Most of the 3724 workers were young with very little accumulated exposure. Some of those who were diagnosed to have pneumoconiosis might have been employed in other companies where the exposure to pneumoconiosis causing dusts occurs. Without an indepth analysis, the cases of pneumoconioses can not be limited to the exposures at HBM&S. A detailed analysis of the problem of pneumoconioses is outside of the scope of this report.

Results indicate that there is a large proportion of HBM&S workers with changes in lung function which are consistent with the obstructive pattern. This could be due to smoking, occupational exposures or a combination of both. Data on smoking show that smoking is a very common habit amongst employees of the HBM&S. It is not certain, however, if smoking alone can be considered responsible for all lung function impairments. Again, a detailed analysis of the role of occupational factors in the etiology of chronic obstructive lung disease is outside the scope of this report. It is hoped, that a research project which is aiming to examine changes in lung function between 1976 and 1983 among the employees of HBM&S will clarify these issues. In that study, the changes in lung function will be related to occupational exposures and the effect of smoking will be accounted for.

TABLE 1

PERCENTAGE DISTRIBUTION OF HBM&S EMPLOYEES BY FEV_1, PERCENT PREDICTED VALUE

SURVEY YEAR

	1976	1977	1978	1979	1980	1981	1982	1983
NUMBER	1031	1291	1506	1422	1423	1597	1660	645
FEV, % PRED.								
80-	74.5	77.9	79.9	76.8	79.2	81.3	83.8	80.2
75-79	10.4	8.7	8.2	8.9	8.4	7.7	7.8	8.8
70-74	6.2	5.5	4.8	5.8	5.0	4.9	3.5	3.9
65-69	2.7	3.1	2.7	3.2	2.7	2.8	2.3	2.8
60-64	2.0	2.2	2.1	2.5	1.3	1.9	1.2	1.4
55-59	1.8	1.4	0.8	0.9	1.0	0.4	0.5	0.8
50-54	2.4	1.2	1.7	2.0	2.4	1.0	0.8	2.2

* 1976 -82: Ages 20-65

** 1983: Ages 35+

All smoking categories

TABLE 2

PERCENTAGE DISTRIBUTION OF HBM&S EMPLOYEES BY FEV_1 /FVC RATIO

SURVEY YEAR

	1976	1977	1978	1979	1980	1981	1982*	1983**
NUMBER	1031	1291	1506	1422	1423	1597	1660	645
FEV_1/FVC,%								
80-	33.8	37.9	37.6	36.1	32.0	31.9	35.7	21.9
75-79	25.6	22.5	25.3	26.4	26.1	27.4	25.8	25.9
70-74	19.5	20.3	17.3	18.0	20.5	20.6	20.8	24.9
65-69	10.5	10.1	10.6	10.3	11.5	10.4	10.2	13.5
60-64	4.8	4.9	4.5	4.9	5.1	5.3	3.9	7.0
55-59	2.8	2.6	2.2	2.3	2.5	2.0	1.9	3.6
-55	2.9	1.7	1.9	2.0	2.2	2.3	1.6	3.3

* 1976 - 1982: ages 20 - 65

** 1983: ages 35+ only

All Smoking Categories

TABLE 3

PROPORTION (%) OF SMOKERS AMONGST HBM&S EMPLOYEES EXAMINED BETWEEN 1976 -1982

SURVEY YEAR

	1976	1977	1978	1979	1980	1981	1982
NUMBER	1031	1291	1506	1422	1423	1597	1660
AGE							
-24	57.3	54.1	54.5	53.6	56.4	53.6	51.7
25-29	60.1	55.7	55.7	57.8	55.5	51.0	59.2
30-34	57.7	57.7	59.3	59.0	59.9	57.8	53.3
35-39	56.2	54.8	54.4	57.1	60.5	55.7	54.5
40-44	52.5	51.8	52.6	46.4	45.6	46.7	50.4
45-49	48.8	44.9	45.2	48.5	47.5	45.0	46.2
50-54	48.3	37.4	42.5	34.9	38.1	42.5	40.7
55-59	46.4	36.4	37.4	38.7	35.9	33.5	30.1
60 +	33.7	35.5	37.5	33.3	35.9	24.3	26.9
TOTAL	52.9	50.0	50.9	49.8	50.6	48.8	50.0

CHAPTER VIII

FEASIBILITY STUDY OF DEATH CERTIFICATES

TABLE OF CONTENTS

	Page
INTRODUCTION	1
IDENTIFICATION OF DEATH CERTIFICATES	1
HBM&S EMPLOYMENT	1
CAUSE OF DEATH	2
AGE AT DEATH	3
DURATION (YEARS) OF EXPOSURE	3
OCCUPATIONAL HISTORY	4
DISCUSSION	4
TABLES	

INTRODUCTION

The purpose of this chapter was to investigate the feasibility to:

1. identify death certificates for residents of Flin Flon;

2. obtain, in addition to the underlying (primary) cause of death, coded on the death certificate, information about any other condition (secondary cause) which could have contributed to death. The underlying cause is the "disease or injury which initiated the train of events leading to death".

3. identify, with the help of the Hudson Bay Mining and Smelting Company (HBM&S), those deceased residents of Flin Flon who had a history of employment with the company;

4. construct, using HBM&S employment records, an occupational history for each worker, i.e. a list of all jobs held in the company including the beginning and the termination date of each job;

5. group job titles into exposure categories defined in the chapter on workers' exposures and achieve a reasonable consensus about grouping with both the management of HBM&S and the representatives of workers.

IDENTIFICATION OF DEATH CERTIFICATES

With the help of the Vital Statistics Division of the Department of Community Services, death certificates were obtained for all individuals who either died in Flin Flon between January 1, 1952 and December 31, 1984 or were coded as permanent residents (defined as usual residence) of Flin Flon and died elsewhere. Non-permanent residents who died in Flin Flon were eliminated from further study.

Between 1952 and 1984, 1,697 permanent residents of Flin Flon died. The number of deaths for periods of five years is shown in Table 1. There were 235 individuals (13.8%) who died before reaching 20 years of age and 1,462 (85.2) who were 20 years or older at death. Of the deceased persons 20 years and over, 931 (63.7%) were males and 531 (36.3%) were females.

HBM&S EMPLOYMENT

Further investigation focused on males 20 years or older at death, since females and males younger than 20 years were unlikely to have been employed by HBM&S. A list of 931 male residents of Flin Flon who died at the age of 20 years or older was submitted to HBM&S to identify those who had been employed by the company in the past. Employment was confirmed for 643 (69.1%) males (HBM&S exposed residents) while 288 (30.9%) had never been employed at HBM&S (HBM&S non-exposed residents). Comparison between the occupation listed on death certificates and

occupational listings obtained from HBM&S gave the following results. Eighty-five percent of the HBM&S exposed residents and 15 percent of non-exposed residents had a mining/smelting occupation listed on their death certificates. On the other hand, 93 percent of male residents with a mining/smelting occupation on their death certificates and 34 percent of those with other occupation on death certificates, had an employment with HBM&S in the past.

CAUSE OF DEATH

Table 2 shows the primary and secondary cause of death available from the death certificates for 643 HBM&S exposed and for 288 non-exposed male residents of Flin Flon. For the purpose of this report, the underlying cause of death coded on death certificates was considered as the primary cause of death. The secondary cause of death was an additional diagnosis listed on the death certificate and not coded as the underlying cause of death.

The most common cause of death was ischemic heart disease (IHD) which was certified as the underlying cause of death for 205 of the 643 (31.8%) HBM&S exposed residents and for 109 of the 288 non-exposed residents (37.8%). Cancer was certified as the underlying cause of death for 177 HBM&S exposed residents (27.4%) and for 60 (20.8%) non-exposed residents. Cancer of the trachea, bronchus, and lung was the most common cancer among HBM&S exposed as well as among non-exposed residents.

Examination of additional diagnoses on death certificates brought attention to 15 cancer diagnoses which had not been coded as the underlying cause of death; 11 of these occurred in HBM&S exposed and 4 in non-exposed residents. Only one of these was lung cancer. Most common were cancers of the lymphoid system (4 individuals) and of the prostate (3 individuals).

Cancer diagnoses were rarely considered as the secondary cause of death. Some non-cancerous diseases were more frequently reported as secondary than as the primary cause of death. Among these, the most prominent was diabetes (1 primary and 30 secondary), chronic obstructive pulmonary disease (COPD, 30 primary and 47 secondary), cirrhosis of liver (9 primary and 12 secondary), mental disorders (4 primary and 18 secondary).

Table 3 shows cancer deaths as the proportion of all deaths for the exposed and for the non-exposed residents, age 20 years or older, in Flin Flon. Rates are shown for cancers certified as primary causes and for combined primary and secondary causes. It can be seen that among the exposed male residents of Flin Flon, 189 out of 643 deaths or 292.4 per 1000 could be attributed to cancer while among the non-exposed, 64 out 288 deaths or 222.2 per 1000 could be attributed to cancer. In HBM&S exposed residents, a larger proportion of deaths were attributed to cancer of the trachea, bronchus, and lung, and to cancer of the

large intestine including the rectum (90.2 and 32.5 per 1000 deaths, respectively) than in non-exposed residents (56.0 vs 17.4 per 1000 deaths respectively). The proportion of deaths due to cancer of the prostate was higher in non-exposed (34.7 per 1000) than in exposed residents (26.4 per 1000). Cancer of the bladder, brain and lymphoid system occurred in small numbers, although almost exclusively in HBM&S exposed residents. (i.e. 9, 3 and 12 cases, respectively; 1, 0 and 1 cases were recorded in non-exposed residents.)

AGE AT DEATH

Table 4 shows the distribution of all male residents (age 20 or older) by age at death. Approximately 40 percent of Flin Flon residents were over 70 years at death. An additional 28% died between the ages of 60 and 69 years. The difference between the HBM&S exposed and non-exposed residents of Flin Flon should also be noticed. While the proportion of those who were between 20 and 49 years old at death was similar in both groups, the proportion of those who were older than 70 years at death was greater among the non-exposed (51%) than among the exposed (34%) residents of Flin Flon. Table 5 shows that similar differences between exposed and non-exposed residents persisted for all cancers and for IHD. The difference between the HBM&S exposed and non-exposed was somewhat smaller for cancer of the trachea, bronchus, and lung. While all 19 non-exposed residents who died of lung cancer were older than 50 years at death, 7 (12%) out of the 58 exposed residents were 50 years or younger at death (Table 5).

A similar conclusion can be derived from Table 6. This table shows the average age at death for all exposed and non-exposed residents of Flin Flon as well as for a few selected causes of death. It can be seen that non-exposed residents died on the average of 4.5 years older than HBM&S exposed residents, i.e. at age 67.0 in comparison with 62.4 years. There was a similar difference between the exposed and non-exposed residents for several causes of death. However, the difference for lung cancer was smaller (65.6 vs 67.0 years, respectively). It should be pointed out, that estimates of the average age at death for selected causes are based on small numbers of subjects, particularly among the non-exposed residents.

DURATION (YEARS) OF EXPOSURE

Table 7 shows the distribution of exposed subjects by duration of exposure for selected causes of death. The average duration of exposure for selected causes of death is also shown.

Seventy-seven subjects (12%) were employed for less than 5 years and 70 (9.8%) subjects for more than 35 years. Approximately 62 percent of individuals were employed by HBM&S for 15 to 35 years of service. The average duration of employment was 21.1 years.

In Table 7, the distribution of the duration of employment is shown for

individuals who died from all cancers, cancer of the stomach, cancer of the large intestine including rectum, cancer of trachea, bronchus and lung, cancer of bladder, lymphoid cancer , leukemia, COPD and IHD. It can be seen that the duration of HBM&S employment varied with the cause of death.

OCCUPATIONAL HISTORY

Occupational histories were constructed for all 543 HBM&S exposed males residents of Flin Flon. With few exceptions, the beginning and the end date of each job held in the company was obtained for each employee. This made it possible to calculate the duration of employment for each job. Jobs were combined into approximately 30 different exposure groups (defined in the chapter on workers exposure) based on type of exposure (for example, underground, machine shop, etc.) and intensity of exposure (up to a maximum of three levels). Thus, an exposure profile was obtained for each worker.

Table 8 shows the proportion of workers who accumulated at least 5 years of employment in an exposure category. This is shown for the exposed residents who died of all causes as well as separately for those who died of (any) cancer, non-cancer cause of death, and for cancer of trachea, bronchus. Table 8 indicates, for example, that out of 645 subjects, there were 197 (30.5%) who had accumulated at least 5 years of exposure in category A (underground).

The comparison of history of exposure (at least 5 years) between exposed residents who died of cancer and those who did not die of cancer is shown in Table 8. There were some differences between both groups. Those who died of any cancer were more likely exposed in categories A, D, I, O, R. Greater proportion of those who died of lung cancer were more likely employed for at least five years in categories A, D, E, G, H, I, K, L, and less likely in S which designates jobs with little or no exposure.

DISCUSSION

This investigation had two purposes. The first was to examine the feasibility of identifying death certificates for residents of Flin Flon and to carry out a limited evaluation of the information on death certificates. The second was to examine the feasibility of constructing the occupational histories for a sample of HBM&S employees.

The investigation has demonstrated that it is possible to identify death certificates for residents of Flin Flon. The information on death certificates is complete and there is no reason to believe that the quality is below the provincial average. Causes of death are certified; the proportion of individuals who were certified to have died of "natural causes" or "ill defined causes" was small. There were only 12 (1.3%) such individuals among 931 males who were 20 years or

older at death. Between 1952 and 1984, there was no evidence that the quality of information changed with time.

Cancers were the most important health concern. It was necessary to verify if cancers diagnosed and mentioned on death certificates were coded as the underlying cause of death. The investigation has shown that there were instances when a cancer was reported on a death certificate but was not coded as the underlying cause of death. The number of such instances was small. Between 1952 and 1984, there were only 15 cancers among males 20 years or older at death which were not coded as the underlying cause of death. These 15 cases represent 5 - 9 percent of all cancers certified as causes of death in this group of males. It should be pointed out that 7 out of these 15 cases were cancers of the prostate and of the lymphoid system and that only one was lung cancer.

This investigation has demonstrated that it is possible to ascertain, for each worker, whether or not he/she was ever employed by HBM&S. This is due to the good record keeping of HBM&S since the beginning of mining and smelting in Flin Flon. Our investigation covered deaths between 1952 and 1984. Some of those who died in the fifties worked for HBM&S in the beginning of the operation. It was as easy to construct the occupational listing for this group of as for those who worked more recently.

On the other hand, there were some problems with assigning an exposure category for some job titles. While this process was straightforward in most instances, it was problematic for job titles which were not specific for an area since the some job title was in several areas with different exposure characteristics (eg. "labourer", "operator"). In many instances it was possible to assign the exposure to such a job title by considering area specific job titles which preceded or were subsequent to the job title in question.

The information available on death certificates as well as the information obtained from the work histories was used for some preliminary descriptive analysis of deaths. Results of this analysis should be used cautiously as the sample of deaths of HBM&S employees analyzed may not be representative of all HBM&S employees or of all HBM&S employees who died between 1952 and 1984. Deaths in the analysis are those which occurred to HBM&S employees who, at the time of death, were considered permanent residents of Flin Flon. Nevertheless, this analysis has provided some interesting results concerning the relationship between age of death and employment with HBM&S, between duration of employment and cause of death and between the type of exposure and cause of death. These relationships need to be examined further. The definitive analysis is beyond the scope of this report.

The analysis of the relationship between age at death and history of HBM&S employment suggests that those residents of Flin Flon who had been employed by HBM&S died younger than those who had never been

employed by HBM&S. These results could be due to a difference in the age distribution between HBM&S exposed and non-exposed population. Such results could also be produced by some selective migration of HBM&S employees out of the boundaries of Flin Flon. There is also a possibility of a different migration pattern for two different populations in Flin Flon, one employed and the other not employed by HBM&S.

Similarly, the findings that the duration of HBM&S employment and the distribution of occupational histories varied with the cause of death suggest a possibility of a relationship between the employment and disease. This question need to be further examined.

TABLE 1

DEATHS IN FLIN FLON RESIDENTS BY

AGE, SEX, AND YEAR OF DEATH

YEAR OF DEATH	AGE AT DEATH				
	< 20 YEARS	≥ 20 YEARS			ALL AGES
		MALES	FEMALES	TOTAL	
1952-54	39	59	38	97	136
1955-59	49	122	43	165	214
1960-64	48	124	49	173	221
1965-69	31	143	81	224	225
1970-74	25	168	98	266	291
1975-79	27	172	101	273	300
1980-84	16	143	121	264	280
TOTAL	235	931	531	1462	1697

TABLE 2

DISTRIBUTION OF CAUSES OF DEATH BY HISTORY OF EMPLOYMENT FOR MALES AGE 20 OR OLDER

	CAUSE OF DEATH			
	PRIMARY		SECONDARY	
	EXPOSED	NON-EXPOSED	EXPOSED	NON-EXPOSED
Cancer				
All	177	60	11	4
Tongue, Mouth, Pharynx	2	2	--	--
Esophagus	2	2	--	--
Stomach	19	6	--	1
Large Intestine & Rectum	20	4	1	1
Pancreas	13	7	--	--
Other Digestive Tract	4	3	--	--
Larynx	3	--	--	--
Trachea, Bronchus, Lung	57	19	1	--
Prostate	14	10	3	--
Kidney	4	1	--	--
Bladder	9	1	--	--
Brain	3	--	--	--
Lymphoid	8	1	4	--
Leukemia	3	2	--	2
Other	11	2	2	--
Diabetes	--	1	23	7
Heart Disease Not IHD	30	14	14	5
IHD	205	109	16	10
Cerebrovascular (Stroke)	50	29	7	2
COPD	18	12	37	10
Cirrhosis of Liver	7	2	7	5
Other Digestive System	7	4	3	--
Kidney Disease	13	8	6	1
Other Genitourinary	2	2	--	--
Respiratory Not COPD	19	6	7	2
Nervous System	4	1	8	4
Mental Disorders	4	--	11	7
Infectious Diseases	24	8	3	2
Suicide	16	6	--	--
Accidents/Violence	53	22	1	2
Other	6	--	2	--
Natural Causes, Ill Defined	8	4	5	3
TOTAL	643	288	161	64

TABLE 3

CANCER DEATHS AS PROPORTION (PER 1,000) OF ALL DEATHS
IN MALES AGE 20 OR OLDER

	PRIMARY				PRIMARY & SECONDARY			
	EXPOSED		NON-EXPOSED		EXPOSED		NON-EXPOSED	
	NO	RATE	NO	RATE	NO	RATE	NO	RATE
Number of Deaths	643		288		643		288	
Cancer Deaths:								
All	177	275.3	60	208.3	188	292.4	64	222.2
Tongue/Mouth/Pharynx	2	3.1	2	6.9	2	3.1	2	6.9
Esophagus	2	3.1	2	6.9	2	3.1	2	6.9
Stomach	19	29.5	6	20.8	19	29.5	7	24.3
Large Inst. & Rectum	20	31.1	4	13.9	21	32.6	5	17.4
Pancreas	13	20.2	7	24.3	13	20.2	7	24.3
Other digestive	4	6.2	3	10.4	4	6.2	3	10.4
Larynx	3	4.7	--	--	3	4.7	--	--
Trachea/Bronchi/Lung	57	88.6	19	66.0	58	90.2	19	66.0
Prostate	14	21.8	10	34.7	17	26.4	10	34.7
Kidney	4	6.2	1	3.5	4	6.2	1	3.5
Bladder	9	14.0	1	3.5	9	14.0	1	3.5
Brain	3	4.7	--	--	3	4.7	--	--
Lymphoid	8	12.4	1	3.5	12	18.7	1	3.5
Leukemia	8	12.4	2	6.9	8	12.4	4	13.9
Other	11	17.1	2	6.9	13	20.2	2	6.9

TABLE 4

DISTRIBUTION OF EXPOSED AND NON-EXPOSED RESIDENTS
BY AGE AT DEATH

AGE AT DEATH	EXPOSED		NON-EXPOSED		TOTAL	
	NO	%	NO	%	NO	%
20-24	33	5.1	12	4.2	45	4.8
30-39	21	3.3	8	2.8	29	3.1
40-49	53	8.2	19	6.6	72	7.7
50-59	125	19.6	31	10.8	157	16.9
60-69	192	29.9	70	24.3	262	28.2
70 +	218	33.9	147	51.2	365	39.2
	643	100.0	287	100.0	930	100.0
Mean ± SD	62.1 ± 15.2		67.2 ± 16.6		63.7 ± 15.8	

* 1 Missing Information

TABLE 5

DISTRIBUTION BY AGE AT DEATH FOR SELECTED CAUSES OF DEATH

AGE	ALL CANCERS				LUNG CANCER				IHD			
	EXPOSED		NON-EXPOSED		EXPOSED		NON-EXPOSED		EXPOSED		NON-EXPOSED	
	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%
20-29	1	1	1	2								
30-39	5	3	0	0					3	1		
40-49	18	10	2	3	7	12			15	7	7	6
50-59	36	19	7	11	10	17	3	16	52	23	14	12
60-69	61	33	16	25	19	33	9	47	74	33	35	30
70+	64	35	37	59	22	38	7	37	78	35	62	53
Total	188	100	64	100	58	100	19	100	222	100	118	100

TABLE 6

AVERAGE AGE (± STANDARD DEVIATION) AT DEATH FOR EXPOSED AND NON-EXPOSED RESIDENTS

	EXPOSED		NON-EXPOSED	
	Mean ± SD	(No.)	Mean ± SD	(No.)
All Causes	62.4 ± 15.0	(643)	67.0 ± 17.1	(288)
All Cancers	64.5 ± 12.0	(195)	72.7 ± 14.5	(63)
Ca Stomach	63.3 ± 11.4	(19)	82.7 ± 12.1	(7)
Ca Large Intestine & Rectum	54.4 ± 15.2	(21)	81.9 ± 10.3	(5)
Lung	65.6 ± 10.7	(58)	67.0 ± 7.4	(19)
COPD	67.4 ± 10.6	(55)	74.2 ± 9.3	(22)
IHD	65.1 ± 10.9	(222)	70.0 ± 11.4	(118)

TABLE 7

DISTRIBUTION OF SELECTED CAUSES BY DURATION OF EXPOSURE AT H.B.M.&S.

YEARS OF EXPOSURE	ALL CAUSES		ALL CANCER		Ca STOMACH		LARGE INT. & RECTUM		LUNG CA		Ca BLADDER		Ca LYMPHOID		LEUKEMIA		COPD		IHD	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
-4	77	12	13	7	4	21	1	5	3	5	1	11	4	33	0	0	4	7	15	7
5-9	45	7	12	6	3	16	2	10	3	5	1	0	0	0	1	13	7	13	12	5
10-14	57	9	18	10	3	16	5	24	3	5	2	22	2	17	1	13	3	6	18	8
15-19	89	14	22	12	1	5	4	19	7	12	0	0	2	17	1	13	7	13	32	14
20-24	102	16	31	17	1	5	2	10	11	20	3	33	2	17	1	13	8	15	45	
25-29	121	19	39	21	4	21	5	24	11	19	1	11	0	0	2	25	9	17	48	22
30-34	78	12	26	14	2	11	1	5	10	17	0	0	0	0	1	13	9	17	28	13
35-39	58	9	21	11	1	5	0	0	10	17	2	22	2	17	1	13	6	11	17	8
40-44	12	2	3	2	0	0	1	5	0	0	0	0	0	0	0	0	1	2	6	3
	641	100.	185	100	19	100	21	100	58	100	9	100	12	100	8	100	54	100	221	100
Total Yrs/ Exp.	13600		4241		308		406		1438		199		180		189		1204		5066	
Average Years Exp.	21.1		22.9		16.2		19.3		24.8		22.1		15.0		23.6		21.9		22.9	

TABLE 8

PROPORTION OF EMPLOYEES WITH AT LEAST 5 YEARS OF EMPLOYMENT IN A SPECIFIED EXPOSURE GROUP

EXPOSURE GROUP	ALL SUBJECTS		ALL CANCERS		ALL NON-CANCERS		LUNG CANCER	
	No.	%	No.	%	No.	%	No.	%
A	197	30.5	61	33.0	136	29.6	21	36.2
B	17	2.6	5	2.7	12	2.6	1	1.7
C	31	4.8	8	4.3	23	5.0	2	3.4
D	25	3.9	10	5.4	15	3.3	3	5.2
E	17	2.6	4	2.2	13	2.8	2	3.4
F	23	3.6	5	2.7	18	3.9	0	---
G	38	5.9	11	5.9	27	5.9	5	8.6
H	62	9.6	19	10.2	43	9.3	6	10.3
I	61	9.4	22	11.9	39	8.5	9	15.5
J	15	2.3	5	2.7	10	2.2	1	1.7
K	5	0.8	3	1.6	2	0.4	3	5.2
L	4	0.6	1	0.5	3	0.6	1	1.7
M	8	1.2	3	1.6	5	1.1	0	---
N	3	0.5	1	0.5	2	0.4	1	1.7
O	32	5.0	11	5.9	21	4.5	3	5.2
P	32	5.0	9	4.9	23	5.0	2	3.4
Q	10	1.5	3	1.6	7	1.5	0	---
R	17	2.6	7	3.8	10	2.2	2	3.4
S	71	11.0	17	9.2	54	11.7	3	5.2
T	2	0.3	2	1.1	0	---	0	---
U	9	1.4	4	2.2	5	1.1	3	5.2

ACKNOWLEDGEMENTS

This report was prepared by invaluable and enthusiastic help of four summer students:

Shari Pierangeli wrote the chapter on "Public Perception of Health Problems in Flin Flon".

Ronald Scrapneck prepared the chapter on "General Environment of Flin Flon".

John St. Godard assisted in the preparation of the chapter on "Working Environment at HBM&S".

Heather Brown assisted in the preparation of the chapters entitled "Morbidity in Flin Flon" and "Feasibility Study of Death Certificates".

We would like to acknowledge the contribution of:

Robert Semenciw, Non-communicable Disease Division, Bureau of Epidemiology, Laboratory for Disease Control, Health and Welfare Canada, for prepration of "The Mortality in Flin Flon".

Dr. N. W. Choi, Manitoba Cancer Research and Treatment Foundation contributed the analysis: "Mapping of Cancer Incidence in Manitoba: Results for Flin Flon".

Larry Strachan, Environmental Management Division of the Department of Environment and Workplace Safety and Health advised on "General Environment in Flin Flon".

M. Kreton, Vital Statistics, Department of Community Services advised on the "Study of Death Certificates".

Wayne Frazer and Ron Typliski, Hudson Bay Mining and Smelting

Bob Imerie and Steve Hammond, the Steelworkers Union

Union and Trade Representatives of Hudson Bay Mining and Smelting

John Elias, Peter Griffin and Carmen Scinocca, Workplace Safety and Health Division, Department of Environment and Workplace Safety and Health.